

# CHAPTER 2

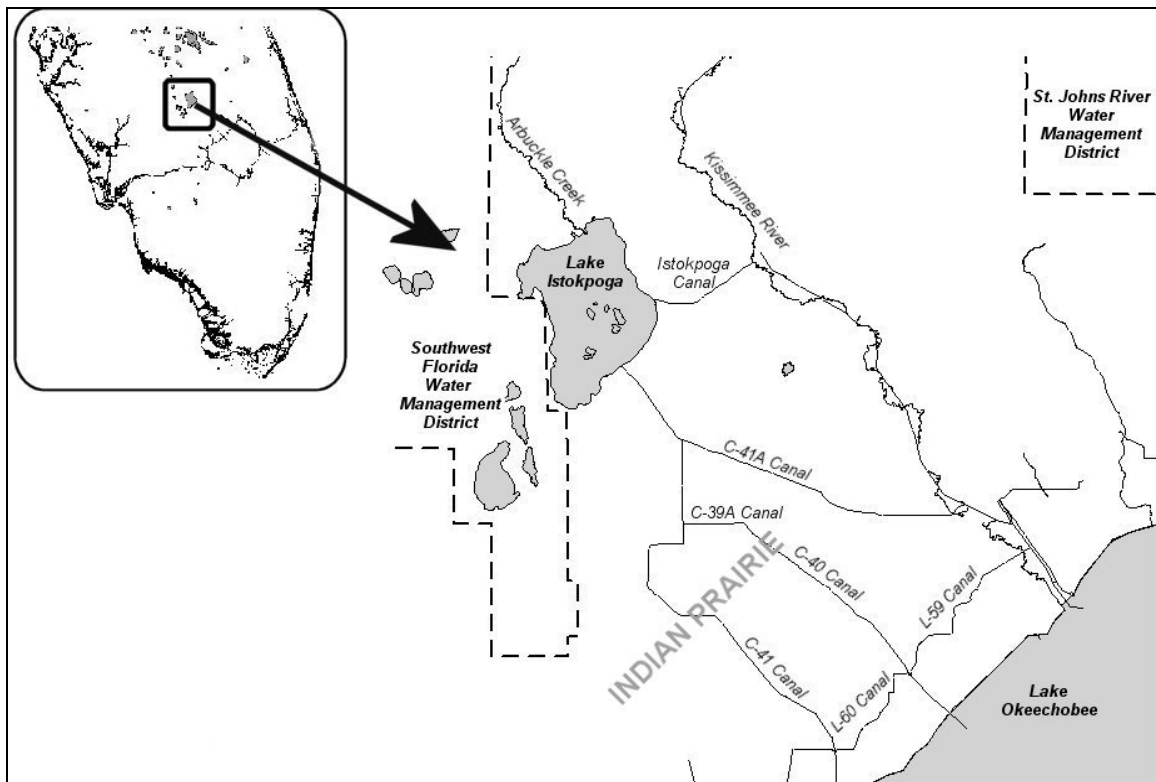
## Description of the Water Body

### INTRODUCTION

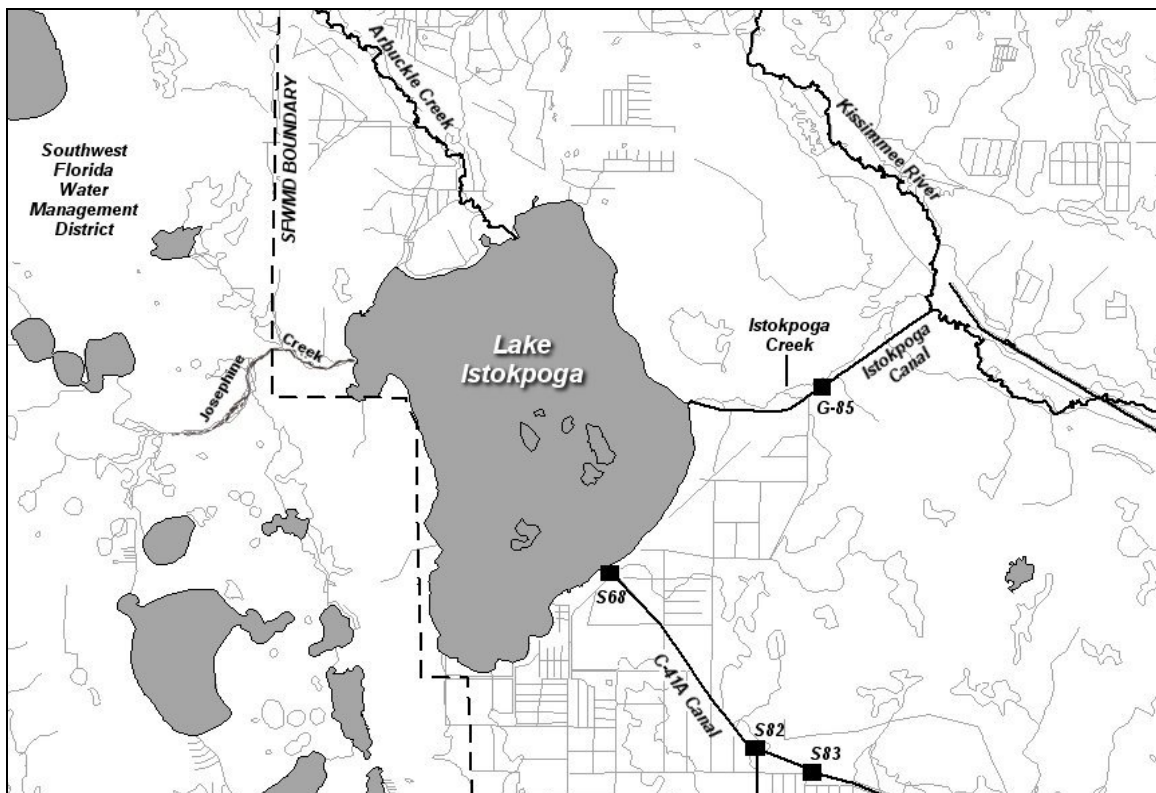
The Lake Istokpoga basin is located northwest of Lake Okeechobee in central Florida within the Kissimmee Basin Planning Area (SFWMD 2000a) (**Figure 2**). This basin drains an area of approximately 920 mi<sup>2</sup> (2,383 km<sup>2</sup>) (Milleson 1978) within Polk and Highlands counties. Approximately two-thirds of the basin is within the Southwest Florida Water Management District (SFWMD), while the remaining portion of the basin and all of the lake is within the SFWMD. Lake Istokpoga resides within the Kissimmee/Okeechobee Lowland Region and the Lake Wales Ridge borders it to the west (White 1970).

Lake Istokpoga is Florida's fifth largest lake at approximately 44 mi<sup>2</sup> (114 km<sup>2</sup>) in size and is shallow with an average depth of 4 feet (ft) (1.2 m) (McDiffett 1981). Direct rainfall, combined with tributary inflows from Josephine and Arbuckle Creeks, provide the majority of surface water inputs to the lake (Walker and Havens 2003). Outflows from Lake Istokpoga are directed either to the Kissimmee River or Lake Okeechobee through a system of canals and water control structures. Water levels in the lake are controlled by the G-85 and S-68 structures (**Figure 3**). The G-85 Structure discharges water into the Istokpoga Canal, which flows eastward to the Kissimmee River. The S-68, which was constructed and became operational in 1962, is a gated water control structure that discharges into the C-41A Canal. Once water enters the C-41A Canal, it is generally routed to the Kissimmee River and/or Lake Okeechobee (**Figure 2**). Historically, Istokpoga Creek provided the only means for channelized outflow from the lake, but significant quantities of overland (sheet) surface water once flowed towards the Kissimmee River and Indian Prairie during times of high water levels.

Lake Istokpoga is a unique regional resource in several ways. It is an important source of water supply for agricultural lands located southeast of the lake (Indian Prairie). The scenic beauty of the lake has encouraged the establishment of waterfront residences along the northern and eastern shores. The lake is also recognized as one of the top fishing lakes in the state of Florida and several annual bass fishing tournaments are held, providing economic benefit to the local economy. Fowl hunting is also a popular sport on the lake and its fringing marshes. Remnant cypress swamps are found along the western half of the lake, providing important habitat for wildlife. Bird watching is a significant recreational activity on the lake; the two larger islands in the southern end of the lake support a large wading bird rookery. Some of the highest concentrations of nesting osprey ever documented have been recorded in wetlands fringing the lake (Stewart 2001) and bald eagles are routinely seen in the area.



**Figure 2.** Major Landscape Features in the Lake Istokpoga Vicinity.



**Figure 3.** Major Drainage Features of Lake Istokpoga.

Besides establishment of a MFL for Lake Istokpoga, the preservation and enhancement of the lake's outstanding natural and cultural values are the goals of several other ongoing projects. These include the reexamination of the Lake Istokpoga regulation schedule as part of the Comprehensive Everglades Restoration Plan (CERP) and examination of water supply concerns and issues as part of the *Kissimmee Basin Water Supply Plan* (SFWMD 2000a). A review of these and other enhancement projects is provided later in this chapter.

## DESCRIPTION OF THE WATERSHED

### Climate, Rainfall and Seasonal Weather Patterns

The climate in the Lake Istokpoga watershed is subtropical with an average summer daily temperature of 85.5° F (29.7° C) and an average winter daily temperature of 61.4° F (16.3° C). The average annual temperature is 75.5° F (24.2° C). Winters are mild with warm days and moderately cool nights that may dip to near freezing after the passing of a cold front. August is typically the warmest month (SFWMD 2000a).

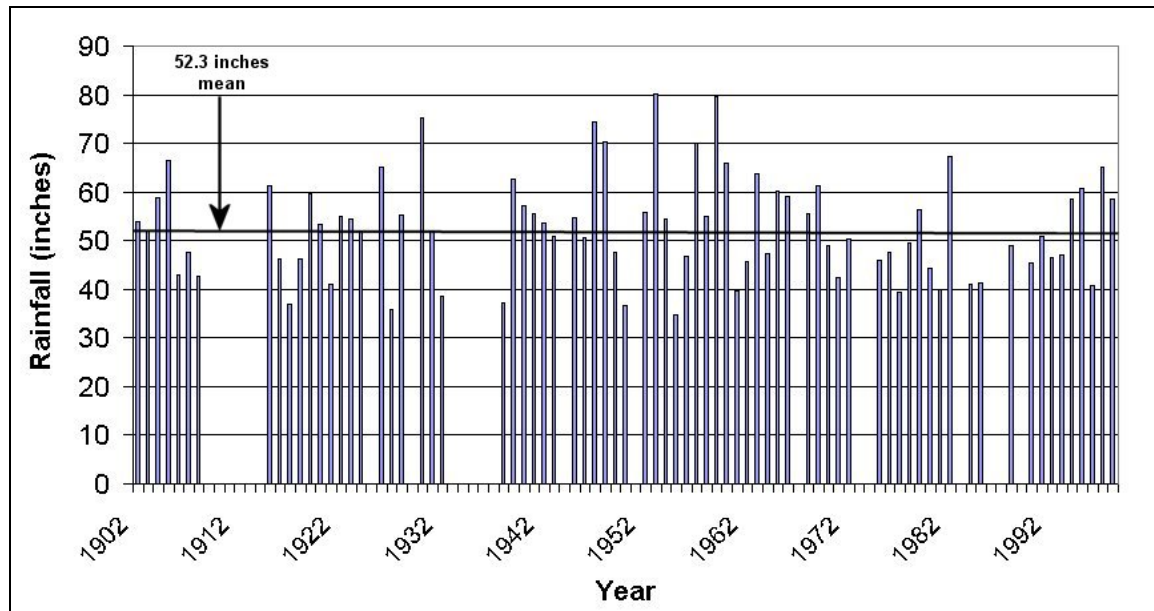
There are two defined seasons, a cool dry season (November through April) and a hot, humid rainy season (June through September). During the rainy season, afternoon thundershowers are common and provide most of the total annual rainfall. Rainfall during the dry season is typically associated with the passing of continental cold fronts. May and October are regarded as transitional months that vary from year to year in rainfall and temperature. During the winter and early spring, some years have long periods of little or no rainfall, resulting in a regional drought condition. In contrast, tropical storms or hurricanes can produce 6 to 10 inches (15 to 25 cm) of rainfall in one day.

Total annual rainfall (1902–1998) within the Lake Istokpoga watershed ranged from 34 inches (86 cm) to more than 80 inches (203 cm) (**Figure 4**). Besides this inter-annual variability, there is also a spatial variability of rainfall amounts across the region. Near Avon Park (northwest of Lake Istokpoga), the long-term average rainfall is 52.3 inches (132.8 cm). However, annual averages are 45.1 inches (105.4 cm) and 39.9 inches (101.3 cm) near Sebring (near the north shore of Lake Istokpoga) and at the S-68 Structure (south shore of Lake Istokpoga), respectively (**Table 1, Figure 5**). Heaviest precipitation occurs during the wet season (June through September) when monthly averages range from 7.5 to 8.6 inches (19.1 to 21.8 cm) (**Figure 6**). On average, the highest average monthly total rainfall of 8.6 inches (21.8 cm) occurs in June with the onset of the rainy season, while the minimum monthly average of 1.8 inches (4.6 cm) occurs in December (**Figure 6**).

Review of the distribution of annual rainfall data from the Avon Park station over time shows that a variance of about 10 percent of the mean ( $\pm 5.23$  inches) occurs about once every three years on average (36% of the 75-year period of record). Extreme dry and wet periods can be defined as a variance of more than 20 percent of the mean ( $\pm 10.46$  inches). Based on this definition, the long-term record shows that an extreme

dry or wet period occurs within the basin about once every three years. Hence, the probability of having a “wet”, “dry” or “average” year is about the same.

Evapotranspiration (ET) is the sum of evaporation and transpiration. Like rainfall, ET is generally expressed in terms of inches of water per year. For the Lake Istokpoga area, ET returns approximately 50 inches (127 cm) of water per year to the atmosphere (Visser and Hughes 1969). The excess of average precipitation over average ET is equal to the combined amounts of average surface water runoff and average groundwater recharge.

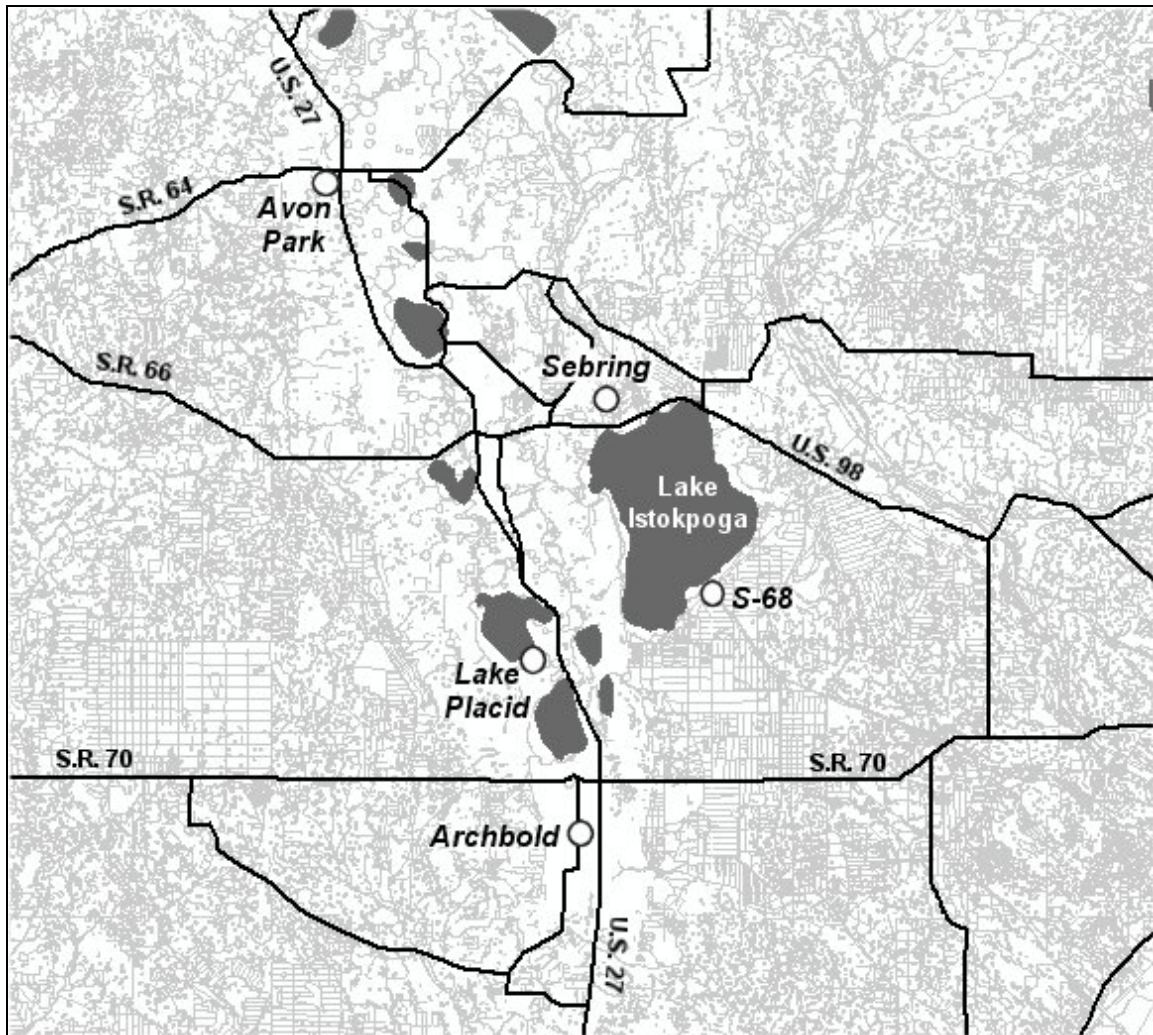


**Figure 4.** Total Annual Rainfall Values, Avon Park Station (1902–1998); only Years with Complete Records are shown (Source: SFWMD’s DBHYDRO Database).

**Table 1.** Long-Term Mean Rainfall Data for Rainfall Stations in Highlands County (Source: SFWMD’s DBHYDRO Database); Locations are Indicated in Figure 5.

Rainfall Station	Average Annual Rainfall (inches)	Years and Period of Record	Maximum Monthly Rainfall		Minimum Monthly Rainfall		% Rain Falling in Wet Season	Primary DBKEY
			Inches	Month	Inches	Month		
Archbold	49.2	53 1929–1995	7.8	Jun	1.6	Dec	65.7	06205
Avon Park	52.3	82 1902–1995	8.3	Jun	1.7	Nov	66.2	06136
Lake Placid	49.7	50 1933–1995	8.1	Jun	1.5	Dec	65.8	06150
Sebring	45.1	26 1972–2002	7.1	Jun	1.5	Dec	63.2	05855
S-68	39.9	26 1966–1998	6.0	Aug	1.3	Dec	62.6	06066

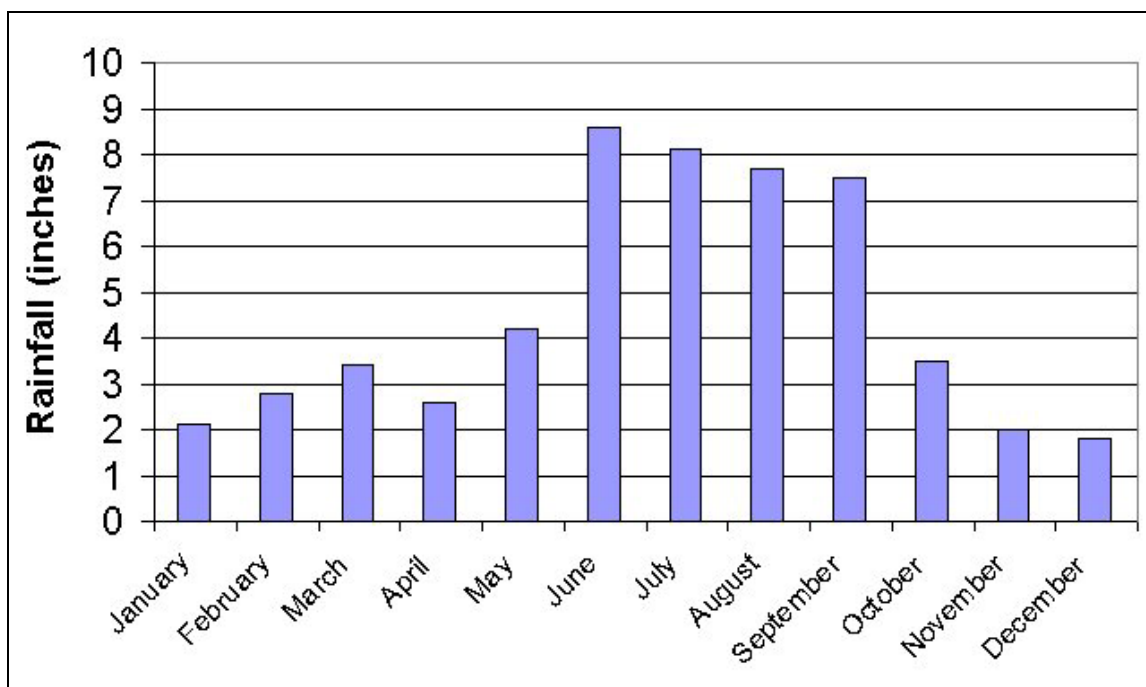




**Figure 5.** Rainfall Stations in the Lake Istokpoga Area; Locations Indicated by Circles.

## Physiography

There are three major physiographic zones found within the region that contains Lake Istokpoga. These zones are described by White (1970) and Scott (1997) as the: 1) Lake Wales Ridge, 2) Osceola Plain and 3) Okeechobee Plain. The Lake Wales Ridge traverses the western edge of the historic Lake Istokpoga water body and is bounded on the east by the Okeechobee and Osceola plains. The Osceola Plain is found mostly in Osceola County, whereas the other zones have a larger geographic distribution. In general, these physiographic features were formed as the Florida peninsula land mass gradually emerged from a retreating sea.



**Figure 6.** Average Total Monthly Rainfall, Lake Istokpoga Basin (1947–1990) (Source: Searcy 1994).

The Lake Wales Ridge is a relic beach ridge/dune system that generally formed during the Pliocene Epoch (c. 1.8 to 5 million years ago) and has elevations exceeding 100 feet (30 m) elevation, National Geodetic Vertical Datum (NGVD) (Scott 1997). The crest of the ridge forms the water divide between the SFWMD and the Southwest Florida Water Management District (SWFWMD). Most of the surface water to the east of this ridge historically drained to the Kissimmee River.

The Okeechobee Plain, which formed with the Osceola Plain during the Paleogene Epoch (c. 23 to 65 million years ago), gradually slopes southward from an elevation of 30 to 40 ft (9 to 12 m) NGVD near the top of its boundary, to about 20 ft (6 m) at the north shore of Lake Okeechobee (Scott 1997). The plain is about 30 miles (48 km) wide and long, with little local relief. Lake Istokpoga is situated on the western Okeechobee Plain adjacent to the Lake Wales Ridge.

## Soils

The overlying sediments in this region are from approximately 1.6 million to 10,000 years old (Tibbals 1990). There are three dominant soil types in Highlands County, each with different compositions and properties. These three soil types are found in distinct physiographic regions: very well drained pure sands are found on the high dunes of the Lake Wales Ridge, flatwood soils are distributed throughout the lowlands between the ridge and the Kissimmee River and organic soils are associated with historical floodplain wetlands (SCS 1989).

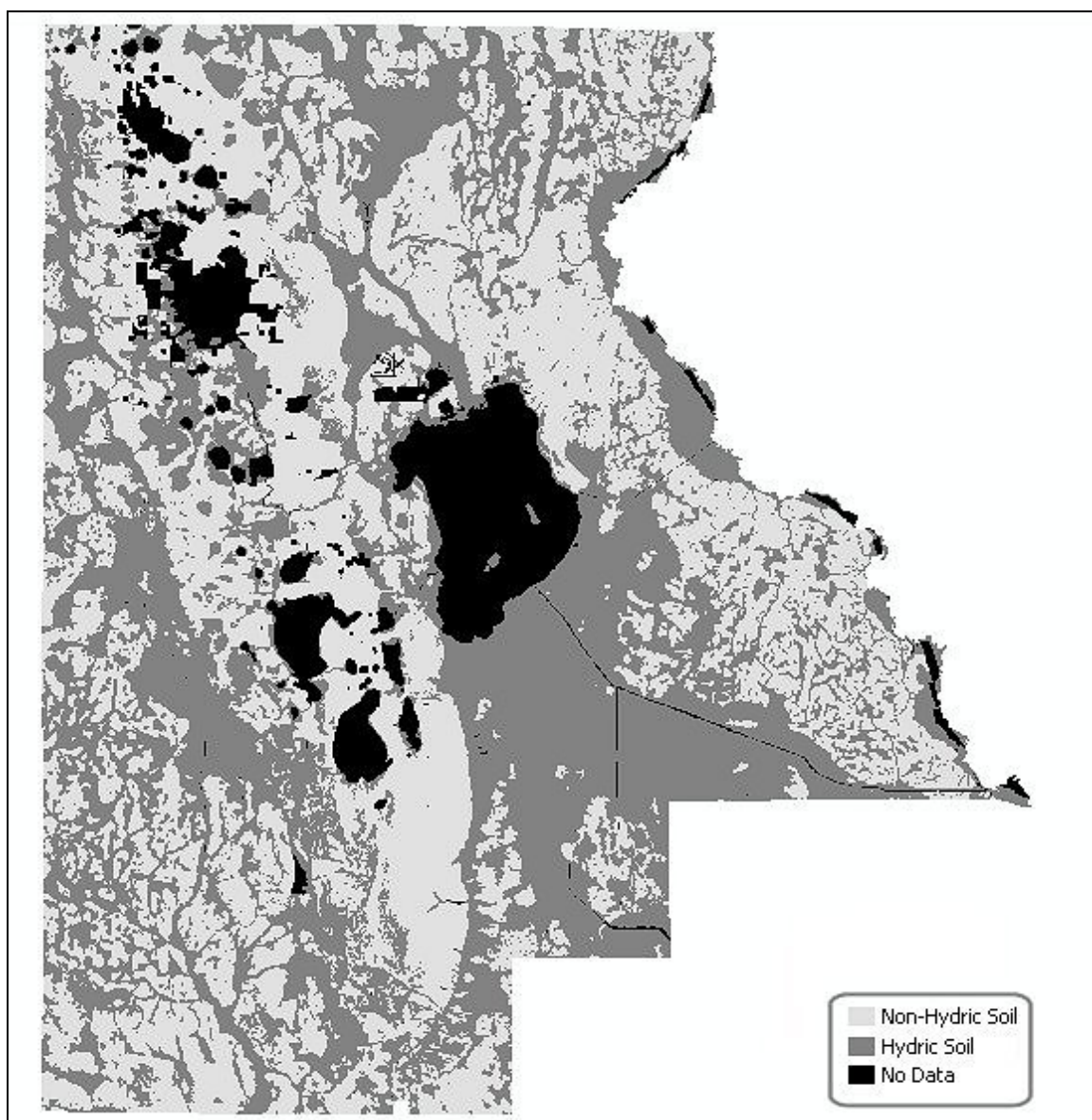
The soils characteristic of the Lake Wales Ridge are deep, pure sands that are relatively sterile, very well to excessively drained and have a low water retention capacity (SCS 1989). These soils are found within the undulating landscapes of Florida's central ridge, which has some of the highest elevations found in central and south Florida. These soils compose a relic dune ridge that runs generally southeast to northwest along the western half of the county, providing a stark contrast to the generally level landscape that surrounds it. Historically, xeric vegetation communities developed on these soils; however, a significant area has been cleared and irrigated to support citrus and other agriculture.

Flatwood soils are the most abundant soil type found within Highlands County. These soils are composed mostly of sand and are found on level and often poorly drained sites (SCS 1989). Often there is standing water for up to a couple of months a year. These soils typically have a spodic layer which can influence the drainage, leaching and runoff characteristics of the site (USDA-NRCS 1999). Flatwood soils can be somewhat acidic.

The third major soil type found in Highlands County is organic soils (peats and mucks). These were formed in poorly drained lowland sites where organic matter (e.g., leaf litter, dead plant material) collected to form the usually porous and darkly-colored soil (SCS 1989). These soils are hydric, meaning they are associated with wetlands and were normally inundated with water for a significant portion of the year (USDA-NRCS 1999). The distribution of hydric soils is a useful indicator of the historic extent of wetlands and reveals the interconnected nature of these features (**Figure 7**). The channels along the major drainage features are evident as darker tones and indicate that most of the wetland systems in this region were highly interconnected. Also evident is a large area to the southeast of Lake Istokpoga where a large wetland once provided periodic surface water connection to Lake Okeechobee and the Kissimmee River. Much of the organic soils south of Lake Istokpoga have been drained and converted to agriculture.

## Land Use

The existing land use in the Kissimmee Basin Planning Area is generally more urban in the north than in the south. Continued urbanization is anticipated in the north, while in the south, agriculture land use in Highlands, Glades and Okeechobee counties is projected to increase through 2020 (SFWMD 2000a). This reflects the general migration of the citrus industry to more southern locations following the severe freezes in the 1980s.

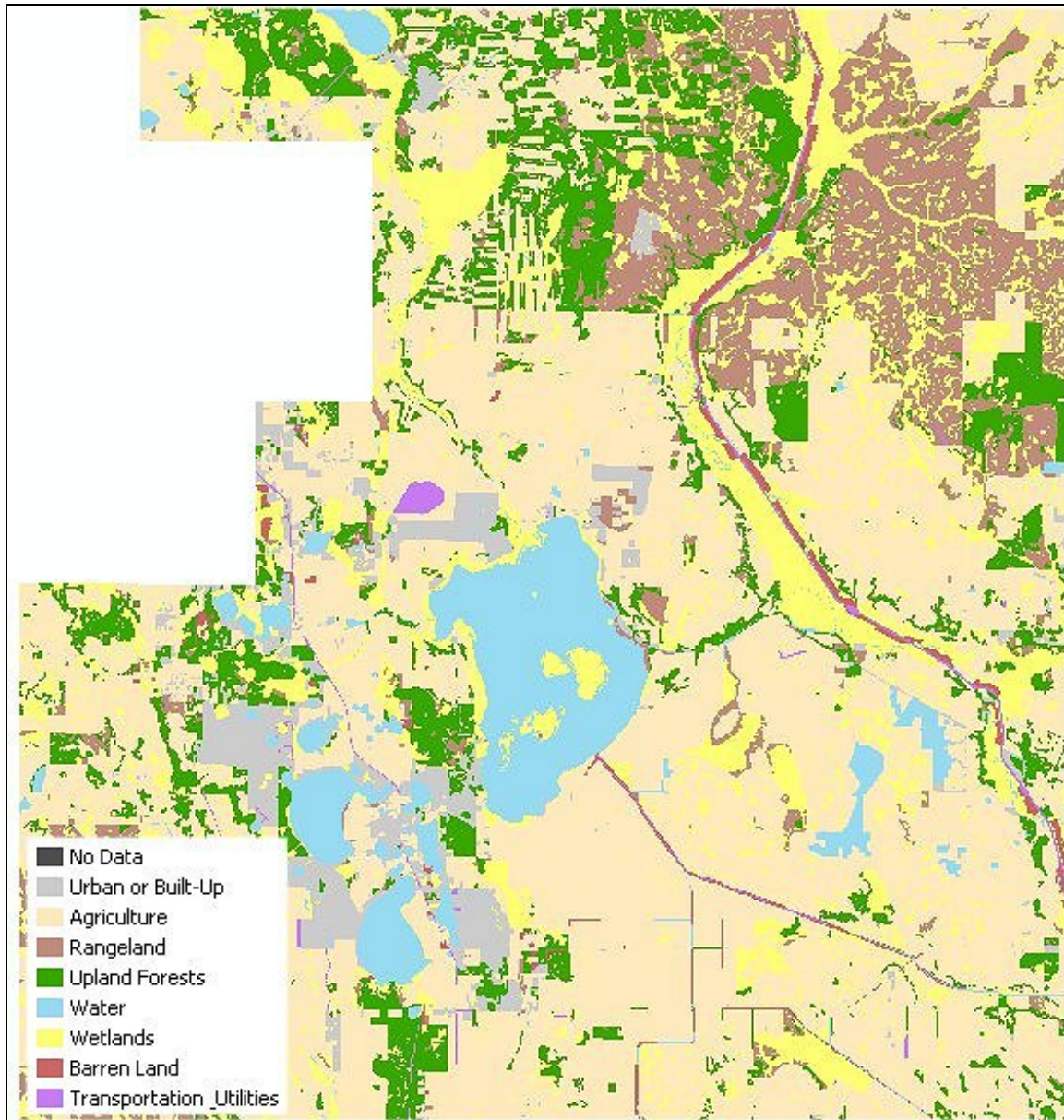


**Figure 7.** Map of Hydric Soils in Highlands County (Source: Zahina *et al.* 2001a).

Land use within Highlands County and the Lake Istokpoga watershed is predominantly agricultural (**Figure 8**). The main agricultural types are pasture lands (including rangeland, which is typically not irrigated), citrus, cropland (including row crops and some sugar cane production) and ornamental landscape plants (“other”) (**Table 2**). Sugarcane, which was almost nonexistent in this basin 20 years ago, increased to roughly 3,300 acres (1,335 hectares or ha) in 1995. Production is expected to increase to 15,300 acres (6,192 ha) by 2020. Urbanization is occurring primarily on the Lake Wales Ridge along U.S. Highway 27, an area just outside of the SFWMD jurisdictional boundary.



South of Lake Istokpoga, in Glades County, lies the Brighton Reservation, one of several Seminole Tribe reservations in Florida. Land use within the reservation includes agriculture, such as rangeland, citrus, aquaculture and sugarcane. Water for crop irrigation is supplied from Lake Istokpoga to these agricultural lands.



**Figure 8.** Major Land Use Types in the Lake Istokpoga Area (Source: FDOT 1995).

**Table 2.** General Land Use Types in Highlands County (Source: FDOT 1995).

<b>Land Use Type</b>	<b>Area (acres)</b>	<b>Percent of Area</b>
No Data	0.4	<0.1
Urban and Built Up (Total)	31,233	5.1
Urban Housing	20,221	3.3
Commercial	984	0.2
Industrial	290	<0.1
Institutional	1,212	0.2
Recreational	672	0.1
Open Land (Urban)	7,854	1.3
Agriculture (Total)	321,949	52.7
Pastureland	231,927	38.0
Cropland	7,835	1.3
Citrus	72,453	11.9
Other Groves	1,022	0.2
Other Agriculture	8712	1.3
Rangeland	36,429	6.0
Upland Forests	71,024	11.6
Water	43,113	7.1
Wetlands (Total)	98,970	16.2
Swamp	41,260	6.8
Marsh	57,711	9.5
Barren Land	4,742	0.8
Transportation and Utilities	3,171	0.5

## Hydrological Features

### Pre-Development Hydrology

SFWMD staff conducted an analysis of historical landscape-level hydrological conditions in the Lake Istokpoga watershed. The analysis examined early documents from General Land Office (GLO) surveys conducted along Lake Istokpoga (GLO 1870) and used this information to determine historical hydrological conditions. Products of this analysis included a map of the pre-drainage landscape identifying prominent features, a determination of the extent of pre-drainage plant communities and a determination of hydrological conditions across the landscape. The methods and results of this analysis are presented in **Appendix C**.

A map of pre-drainage features in the Lake Istokpoga Watershed is shown in **Figure 9**. Surface water inflows to Lake Istokpoga originated from tributaries to the north and west: Arbuckle Creek, Josephine Creek (called “Leslie Creek” in the original maps), Apthorp Creek and Cram Creek. A fringe of wetlands surrounded the lake, ranging from “boggy swamp” and “bay galls” along the western shore to sawgrass marsh from Istokpoga Creek to the south end of the lake.

## Current Hydrology

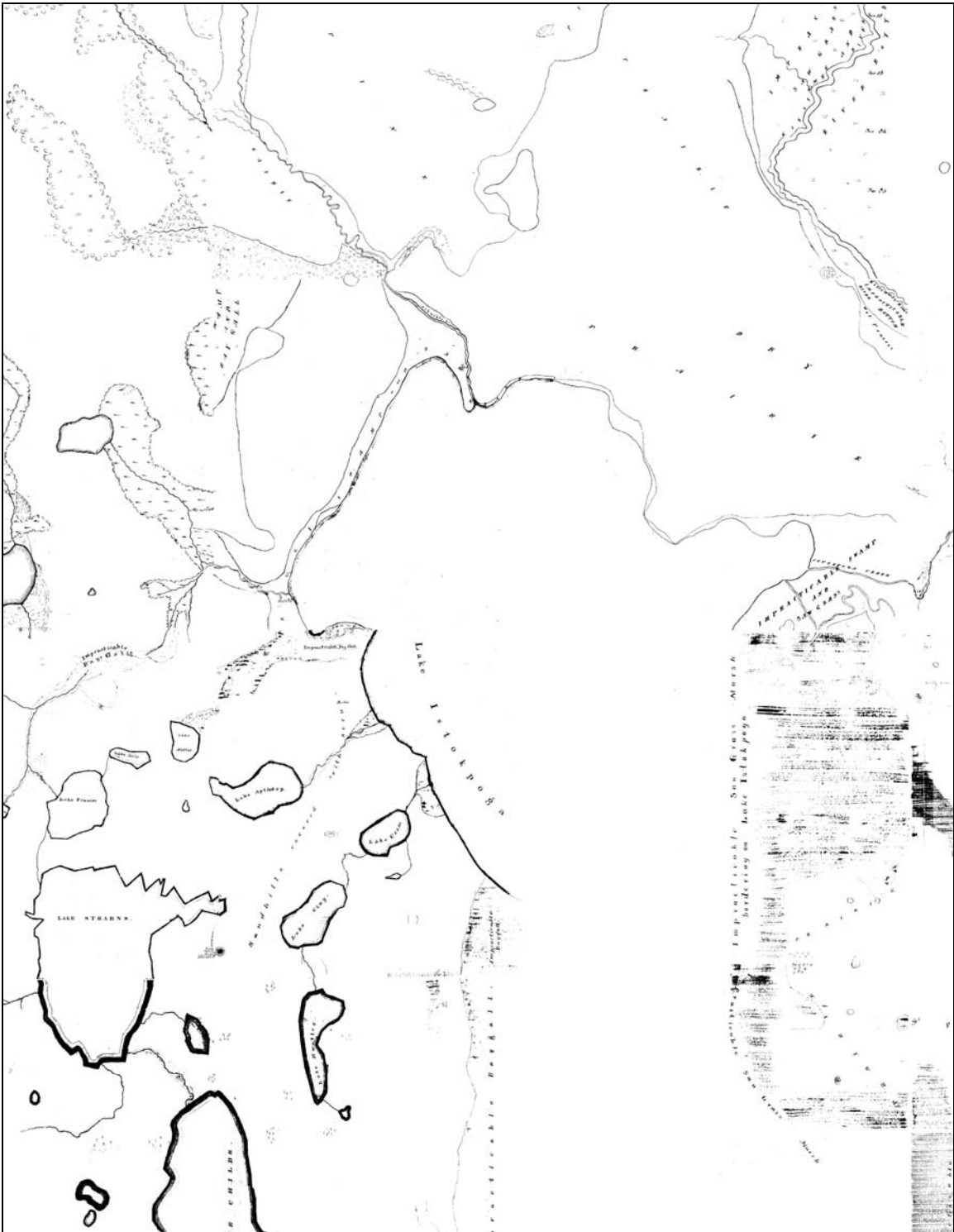
### Major Aquifer Systems

Three major aquifer systems occur in Highlands County: the Floridan (FAS), the Intermediate (IAS) and the Surficial Aquifer Systems (SAS), each with a different potential for use as a water resource (**Table 3**).

The potential freshwater yields from the SAS vary with location, but are usually less than 100 gallons per minute (GPM). In Highlands County, the SAS is used to provide water for cattle lots and residential self-supply. Generally the SAS produces water of potable quality, although some isolated areas may contain high iron and organic concentrations.

The IAS contains isolated beds of sand and gravel, which yield large amounts of good quality water. These beds are important water supply sources to localized areas along the upland ridge. Since the producing zones are discontinuous, the IAS is not considered to be an important potential source of public or large-scale agricultural water supply for Highlands County. The main use of this aquifer is for residential supply.

The FAS is the most important source of water in Highlands County. It is composed of several zones with varying productivity. Wells tapping the most productive zones of the FAS are capable of yielding from 500 to 1,500 GPM (SFWMD 2000a). Water quality varies with depth and location, becoming increasingly mineralized with depth and distance to the south. With the exception of the southeast corner of the county, water quality suitable for most uses can be found as deep as the Lake City Limestone (**Table 3**). All major potable water systems in Highlands County withdraw from the FAS, except for the city of Lake Placid, which withdraws water from Lake Sirena. The FAS is also the primary source of water for citrus irrigation.



**Figure 9.** 1870 Map of the Lake Istokpoga Watershed (Source: GLO 1870).

**Table 3.** Groundwater Systems in Highlands County (Source: SFWMD 2000a).

Hydrogeologic System	Geologic Unit	Thickness (feet)	Water Resource Potential
Surficial Aquifer System	Undifferentiated Clastic Deposits and Tamiami Formation	40–200	Except for isolated areas with high iron and organics, produces small to moderate amounts of good quality water. Furnishes residential self supplied and livestock watering locally throughout the county.
Intermediate Aquifer System	Hawthorn Group	300–650	Confining unit for the Floridan Aquifer System. Isolated beds of sand and gravel yield large amount of water locally along the ridge, but they are discontinuous. Not an important source of water over most of the county.
Floridan Aquifer System	Suwannee Limestone Ocala Limestone Moody's Branch Formation Avon Park Limestone Lake City Limestone	0–80 150–250 50–150 200–300 >400	Most important source of water in Highlands County. Productivity tends to increase with depth. Total dissolved solids, sulfates and chloride concentrations increase with depth and distance to the south from the Highlands Ridge, but water of a quality acceptable for most uses can be found as deep as the Lake City Limestone.
	----- Oldsmar Limestone Cedar Keys Limestone	----- >600 >670	----- Water is too highly mineralized for most purposes.

### Relationship between Groundwater and Surface Water

The relationship between a surface water feature and the underlying groundwater system is often one of the most difficult hydrological features to characterize. This relationship is based on the hydraulic characteristics of each aquifer and the thickness and type of soils separating the two features. When surface water has a higher water elevation than the water table, these surface water bodies provide seepage into the local shallow groundwater system. Examples of surface water bodies include ephemeral ponds on the soil surface following a rainfall, rivers, canals and wetlands. Conversely, when the water level of a surface water body is lower than the water table, groundwater discharge may occur. The rate at which this transfer occurs is dependent on the difference in these two levels, as well as the permeability and thickness of the materials separating the two aquifers.



The FAS experiences both natural and artificial recharge. Natural recharge of the FAS within the Lake Istokpoga Watershed occurs along the Lake Wales and Bombing Range ridges. These areas represent locations where the differences in surface and FAS levels are greatest, and the thickness of the IAS is thinnest or breached by karst activity. Recharge areas are often evident as potentiometric highs on the surface of the FAS.

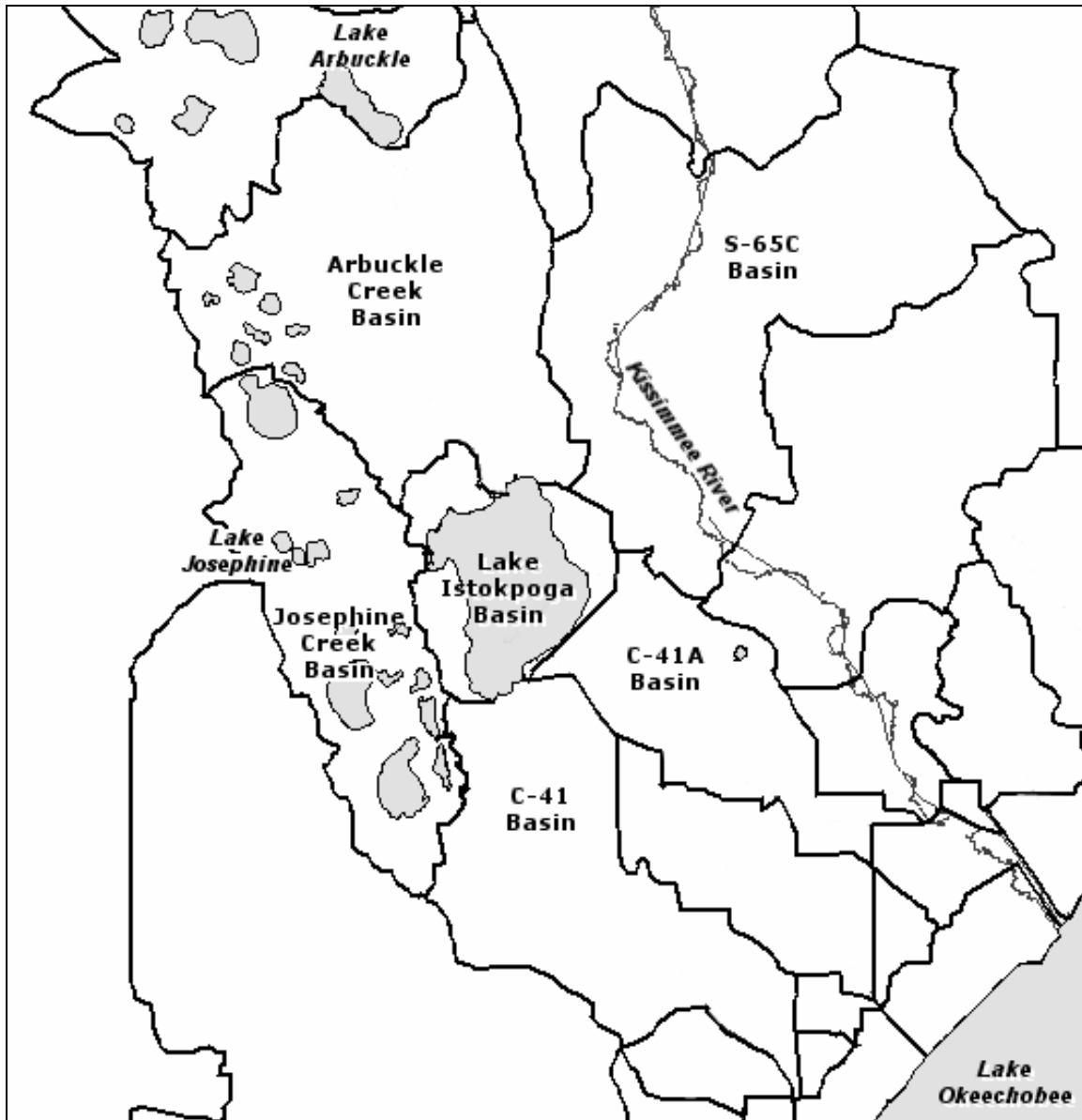
### Surface Water Hydrology

Lake Istokpoga is located within the Lower Kissimmee River Basin, which also includes the tributary watersheds of the Kissimmee River between the outlet of Lake Kissimmee (S-65) and Lake Okeechobee. The general movement of surface water within the Lake Istokpoga area includes inflow from areas adjacent to the subbasins, storage within the basin and outflow to the Kissimmee River and Lake Okeechobee. In general, rainfall on the basin is directed to one of the main surface water hydrological features and passes through Lake Istokpoga. Because of the large size and shallow dimensions of the lake, rainfall may be lost by evapotranspiration or is routed to the Kissimmee River, to Indian Prairie for agricultural withdrawals or to Lake Okeechobee. Water stored within Lake Istokpoga or in lakes within the Lake Wales Ridge may also provide groundwater recharge.

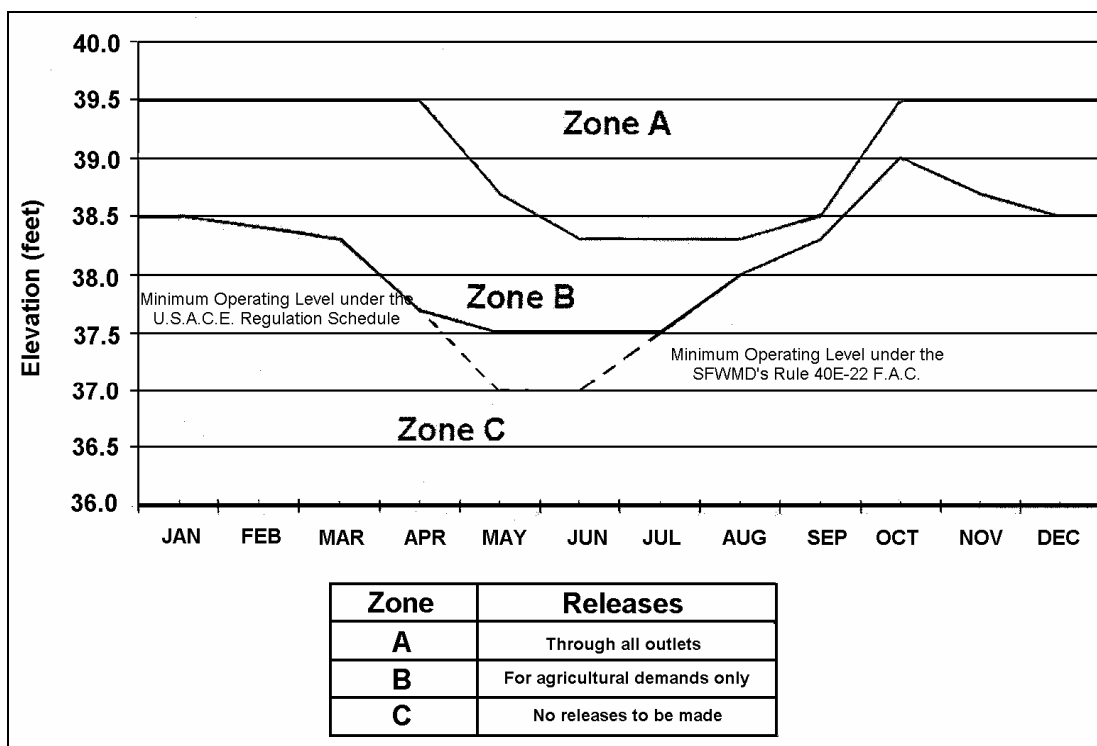
The subbasins that drain into Lake Istokpoga (**Figure 10**) cover some 920 mi<sup>2</sup> (2,383 km<sup>2</sup>) and contain more than 50 lakes (Milleson 1978). Several S-65 subbasins lie along the length of the Kissimmee River and C-38 Canal, but only the S-65C subbasin may influence Lake Istokpoga since some water from the lake enters this basin via the Istokpoga Canal when lake levels are high. The C-40/C-41 subbasins receive water from Lake Istokpoga and pass it on to the Kissimmee River and Lake Okeechobee. Lake Istokpoga contributes between 10 to 15 percent of the total flow into Lake Okeechobee (Davis and Marshall 1975, SFWMD 2003b).

There are several primary features of the Lake Istokpoga watershed that provide surface water drainage. Tributary inflows to Lake Istokpoga include Arbuckle Creek, Josephine Creek and smaller inputs provided by drainage canals from surrounding lands. Arbuckle Creek, which originates at Lake Arbuckle, drains a large agricultural tract to the north (McDiffett 1981). The Arbuckle Creek subbasin is mostly within the SFWMD jurisdiction, but crosses the SFWMD/SFWMD boundary along its western area. Josephine Creek receives water from Josephine Creek and Yellow Bluff Creek subbasins, both of which are almost entirely in the SFWMD. Josephine Creek carries water from more than 30 lakes on the Lake Wales Ridge to Lake Istokpoga (McDiffett 1981).

The Lake Istokpoga subbasin includes the lake and lands to the west-southwest of the lake. Most of the land portion of this subbasin lies within the SFWMD. Water levels in Lake Istokpoga are controlled by regulating outflows through water control structures (S-68 on the south end of the lake and the G-85 on Istokpoga Canal) and guided by a regulation schedule adopted by the U.S. Army Corps of Engineers (USACE) and the SFWMD (**Figure 11**).



**Figure 10.** Watershed Basins in the Lake Istokpoga Vicinity.



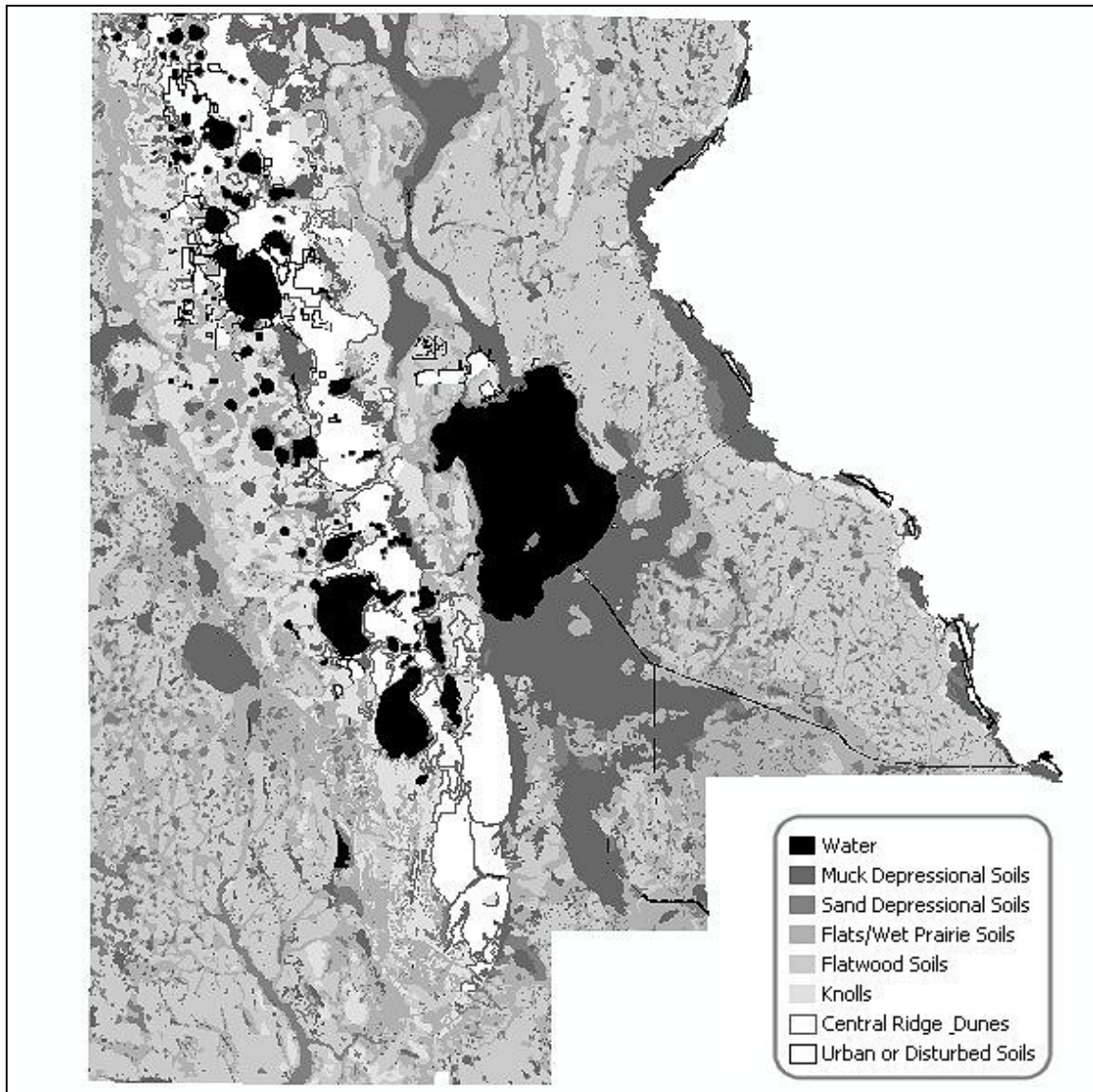
**Figure 11.** Regulation Schedule for Lake Istokpoga.

The relative position of soil types within the landscape provides an indication of historical flowways and drainage features that otherwise would not be apparent (Zahina *et al.* 2001a). A map of natural soils landscape positions within Highlands County (**Figure 12**) shows several prominent features. These include Arbuckle Creek with its associated floodplain to the north of Lake Istokpoga and the lowlands to the south of Lake Istokpoga, which formed a wet-season flowway to Indian Prairie, Lake Okeechobee and the Kissimmee River. Today this area is crossed with numerous drainage canals and has been converted to agriculture.

### Lake Istokpoga

Lake Istokpoga (27° 23 N, 81° 17 W) is the fifth largest natural lake in Florida. The lake area is approximately 27,692 acres (11,207 ha), but this varies considerably with surface water elevation. In addition to supporting a vast variety of fish and wildlife resources, the lake also acts as a source of water supply to the Indian Prairie basin via the C-41/C-41A canal system, which drains to the Kissimmee River and Lake Okeechobee. Recreational boating, fishing and hunting are the primary lake activities.

Using a depth contour (bathymetric) map of Lake Istokpoga (**Figure 13**), the stage-area and stage-volume relationships were determined (**Figure 14**). The stage-area relationship indicates an almost linear relationship between stage and area, with a breakpoint at the 40 ft (12.2 m) contour. Surface area is approximately 26,700 acres (10,800 ha) at a surface water level of 35.1 ft (10.7 m) mean sea level and increases to 28,700 acres (11,600 ha) at 40.0 ft (12.2 m) (VanArman *et al.* 1993). Area then increases



**Figure 12.** Natural Soil Landscape Positions Map of Highlands County; Darker Tones Indicate Soil Types that are Lower in the Landscape and Display a General Topographical Gradient (Source: Zahina *et al.* 2001a).

rapidly with an increase in water level so that the lake covers 34,400 acres (13,900 ha) at a water level of 43 ft (13.1 m) mean sea level (VanArman *et al.* 1993). The relationship between lake volume and water levels follows a similar linear relationship from approximately 62,500 acre-ft (75 million m<sup>3</sup>) at a water level of 35 ft (10.7 m) to 292,000 acre-ft (360 million m<sup>3</sup>) at 43 ft (13.1 m).



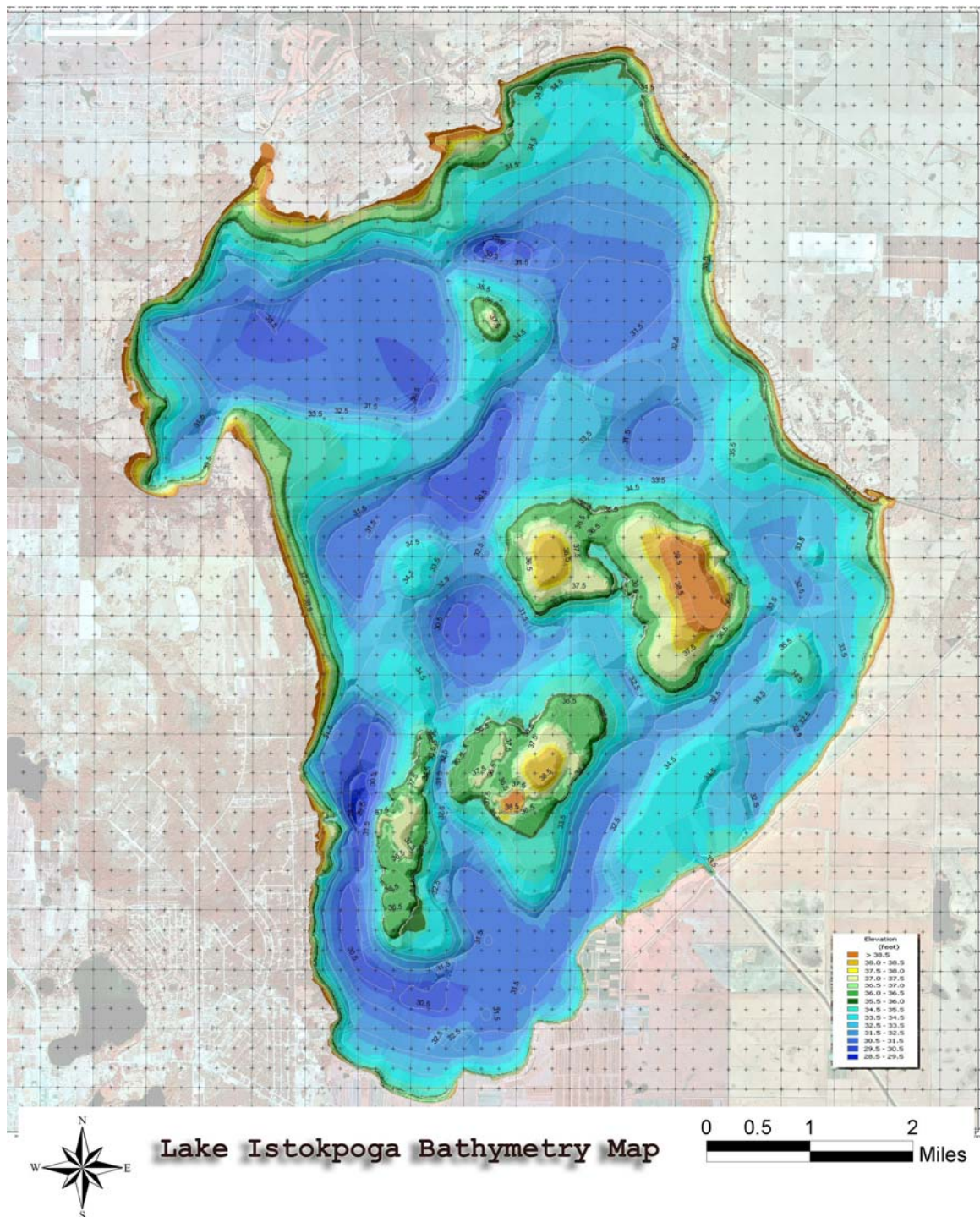
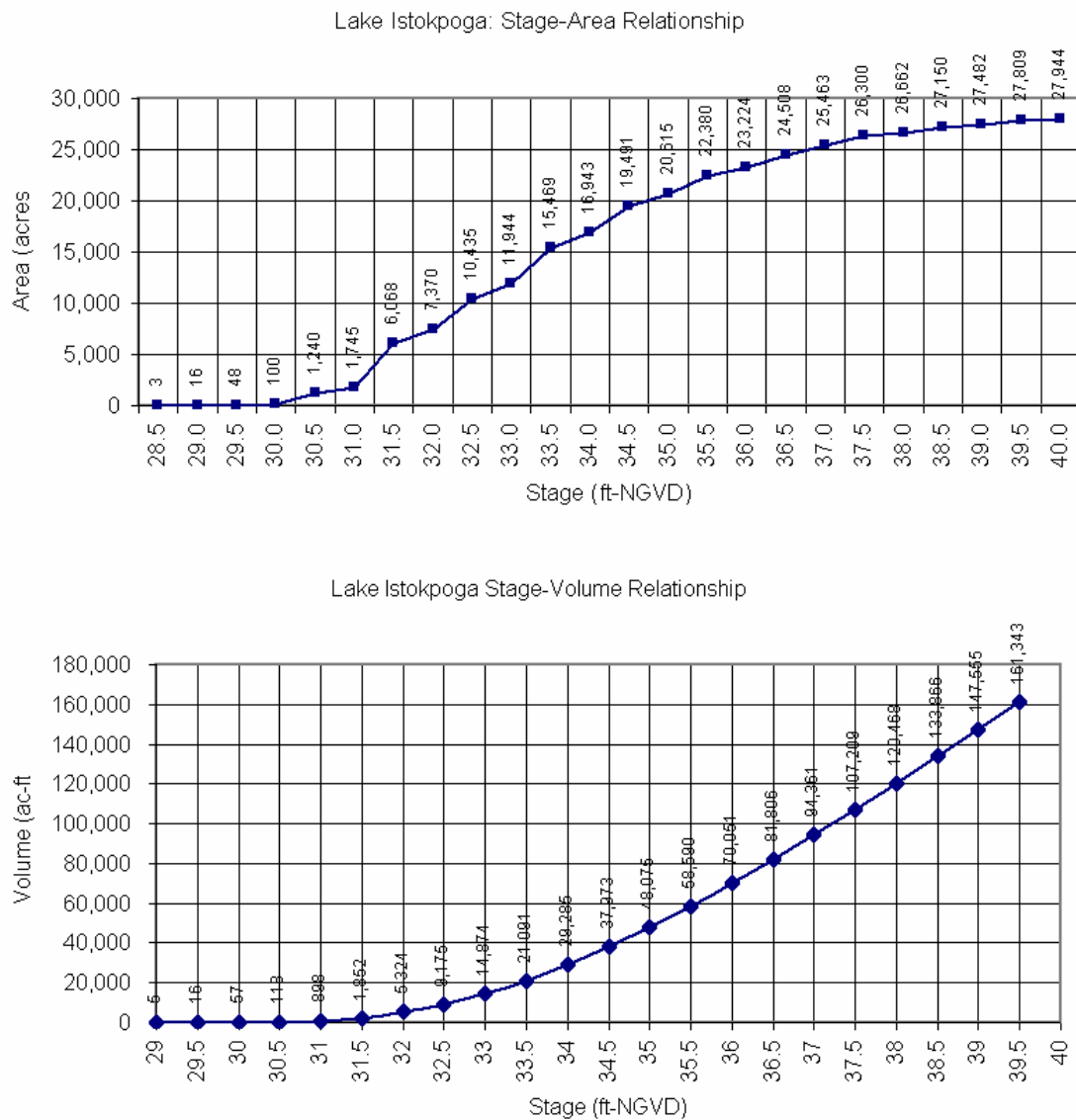


Figure 13. Lake Istokpoga Bathymetric Map (Source: ReMetrix 2003).

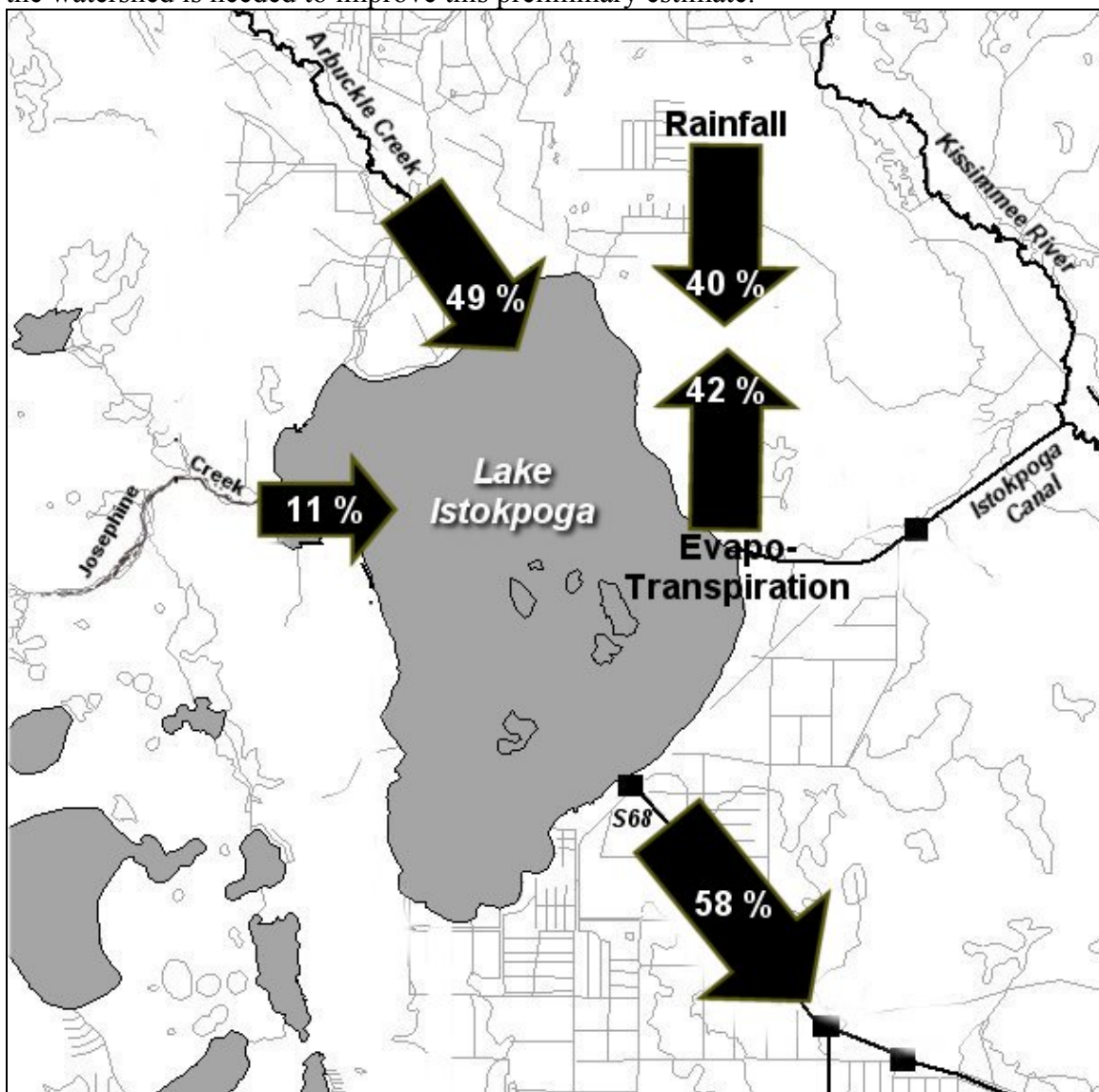




**Figure 14.** Stage vs. Area and Stage vs. Volume Relationships for Lake Istokpoga (Source: derived from bathymetry developed by ReMetrix 2003).

### Lake Istokpoga Hydrological Budget

A simplified water budget was calculated for Lake Istokpoga from existing data sources and is presented in **Appendix D. Figure 15** provides a graphic summary of the water budget for Lake Istokpoga for a 12-year period of record (1990 to 2000) based on a water year (water year = May through April). Measured flow data from Arbuckle Creek is available; however, flow data from Josephine Creek may underestimate total inputs as flow measurements are collected a considerable distance upstream of Lake Istokpoga. These data do not include some potential contributions from groundwater and other surface flows. Evapotranspiration (ET) comprises the least known component of the water budget and a standard annual loss of 50 inches (Visser and Hughes 1969) was used. A better understanding of the temporal and spatial variations in rainfall and ET over the watershed is needed to improve this preliminary estimate.



**Figure 15.** Major Sources of Water Inputs and Losses from Lake Istokpoga.

Tributary inflows (Arbuckle and Josephine Creeks) are the largest source of water for the lake, representing an average of 60 percent (approximately 218,000 ac-ft) of all measured water entering Lake Istokpoga. Unmeasured flows entering from drainage ditches, direct surface water runoff and groundwater seepage from areas surrounding the lake contribute additional water. Walker and Havens (2003) have estimated that up to 17 percent of total inflow to the lake may be from ungauged sources. Rainfall accounts for most of the remaining inputs (possible groundwater inflows are unknown). The primary outflow from Lake Istokpoga is through the S-68, accounting for 58 percent (approximately 233,000 ac-ft) of water losses. Evapotranspiration returns an estimated 118,000 ac-ft of water to the atmosphere each year (42 percent of water losses). Other unmeasured water losses occur through the Istokpoga Canal and may also occur through groundwater. A comparison of seasonal water budgets indicates that there is a surplus of water during the wet season and a deficit of water during the dry season (see **Appendix D**).

Consumptive use types that depend directly on Lake Istokpoga include self-supplied residential (groundwater) withdrawals and releases to agricultural users in the Indian Prairie through the S-68. Self-supplied residential withdrawals are not considered significant groundwater and surface water users within the Lake Istokpoga area. However, agricultural withdrawals can be significant (**Table D-5, Appendix D; Table 4**). An analysis of consumptive use withdrawals by permit and annual pumpages reported for selected permits was conducted (**Appendix D**). The total annual maximum volume of water permitted in the Indian Prairie is 126,380 ac-ft. However, actual usage is typically less than one-third of the amount of water permitted (**Table 4**). A comparison of the maximum annual allocation for all permits with the volume of water discharged to the Indian Prairie through the S-68 indicates that there is typically enough water to meet maximum demands in most years. However, in below-average rainfall years there may not be enough water discharged from the S-68 to meet maximum demands.

**Table 4.** Summary of Annual Pumpages Reported for Indian Prairie Users (1998-2003); Units are Water Volume Expressed as Acre-Feet.

Permit	Annual Permitted	Average Actual Pumpage	Percent Used
19-W	49,625	15,021	30
332-W	3,288	682	21
49-W	5,670	1,765	31
117-W	1,707	278	16
23-W	3,684	980	27
120-W	5,331	273	5
129-W	5,988	1,140	19

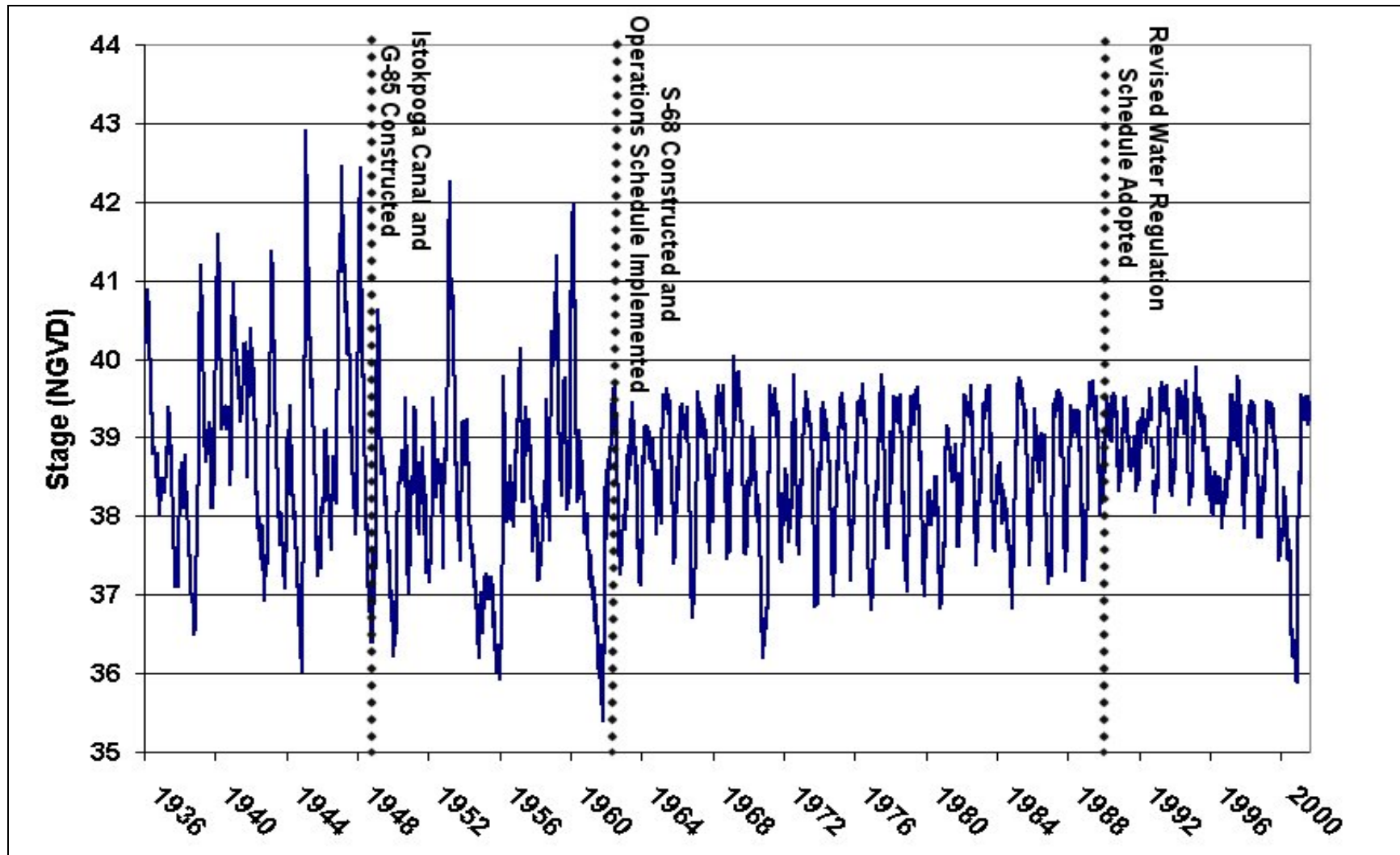
## Drainage and Hydrological Alteration of Lake Istokpoga

Vegetation communities surrounding Lake Istokpoga developed in response to a natural hydrological cycle that maintained these systems for hundreds of years. Changes to this hydrological regime in recent decades have resulted in impacts to the resource. To help prevent periodic high water from harming adjacent agricultural and residential development within and outside the lake's floodplain, Istokpoga Creek was channelized into Istokpoga Canal and the G-85 Structure was constructed (1948–1949) to control discharge from the lake to the Kissimmee River. In 1962, natural high and low stages were eliminated from the lake as a result of construction of the S-68 Structure, which drains Istokpoga into the C-41A Canal (**Figure 16**). These flood control projects reduced the lake's average annual fluctuations from 6 feet to less than 2 feet (**Figure 16**). The annual regulation schedule requires lowering the lake during summer to provide storage for seasonal high rainfall and tropical weather events. Yearly high levels are allowed during the winter when flooding potential is low. This schedule is opposite from the natural annual cycle in which the lake historically rose to its highest level in the summer and receded during drier winter months.

## Lake Istokpoga Regulation Schedule

The S-68 discharges water from Lake Istokpoga southwest into the C-41A Canal, then into associated downstream canals where it becomes available for consumptive use or is discharged to the Kissimmee River or Lake Okeechobee. Water releases from the S-68 have followed an operational schedule since its construction. The operational schedule was more recently reexamined as part of a modeling study funded by the U.S. Army Corps of Engineers (Searcy 1994) and currently, water releases from the lake are made in accordance with the regulation schedule (**Figure 11**). The regulation schedule has been adopted as part of the SFWMD's water shortage rule (40E-22, F.A.C.). This regulation schedule recognizes three management zones that vary by month and season, each with water release guidelines. When water levels are within Zone A, water is discharged through all controlled lake outlets. When water levels are within Zone B, water discharge is discretionary and may be released for agricultural demands. When lake levels fall into Zone C, no releases are to be made.

The final *Central and South Florida Flood Control Project Comprehensive Review Study* (Restudy) (USACE and SFWMD 1999) submitted to Congress in April 1999 recommended the SFWMD and the USACE review the regulation schedule for Lake Istokpoga. The purpose of this effort is to examine the basin with a goal of enhancing fish and wildlife benefits and developing a long-term comprehensive management plan. This project has since been combined with the CERP Lake Okeechobee Watershed Project.



**Figure 16.** Water Level Stage on Lake Istokpoga at the S-68 Structure Site (1936–2000) (Source Data: SFWMD's DBHYDRO Database).

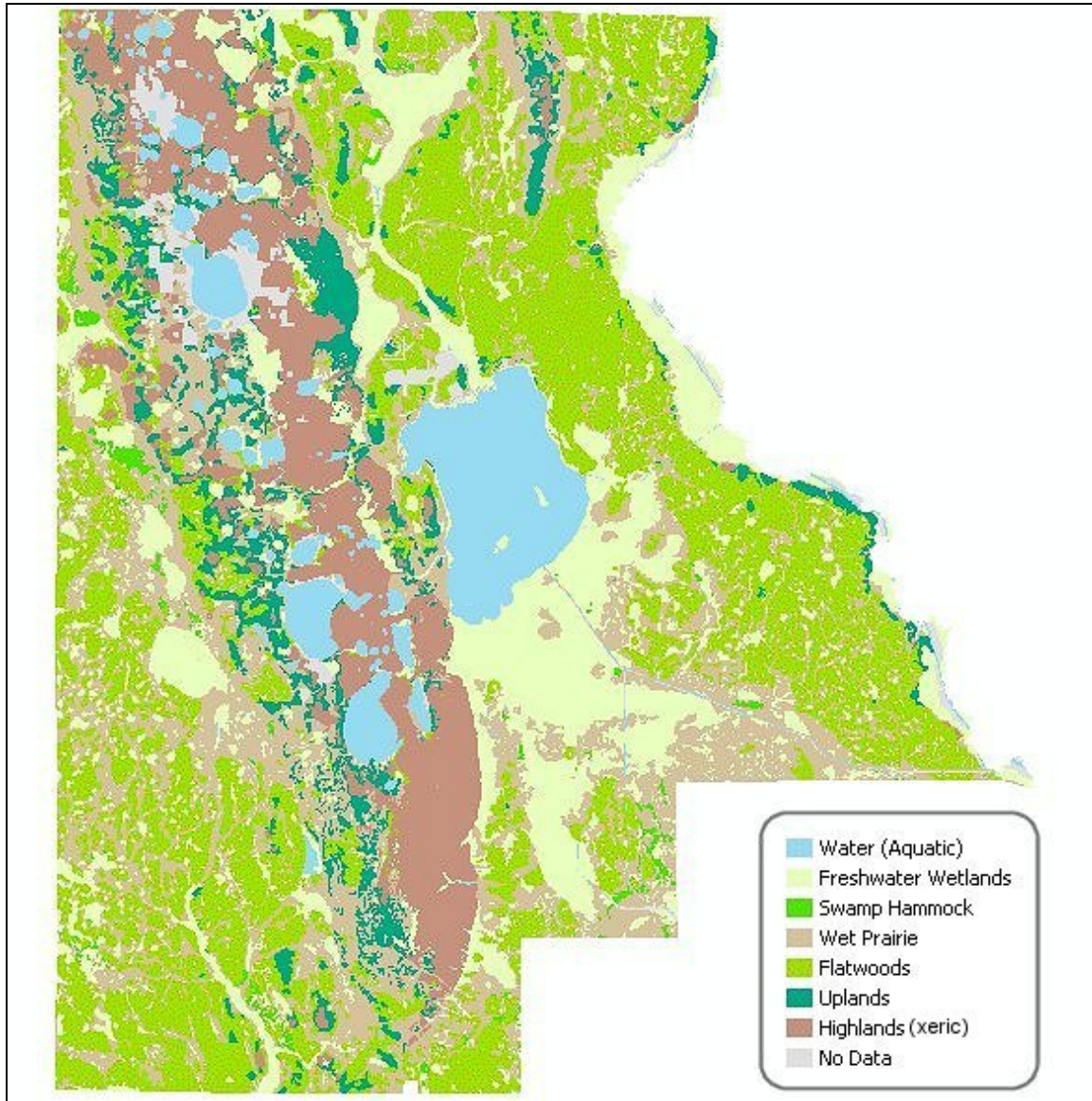


## BIOLOGICAL RESOURCES

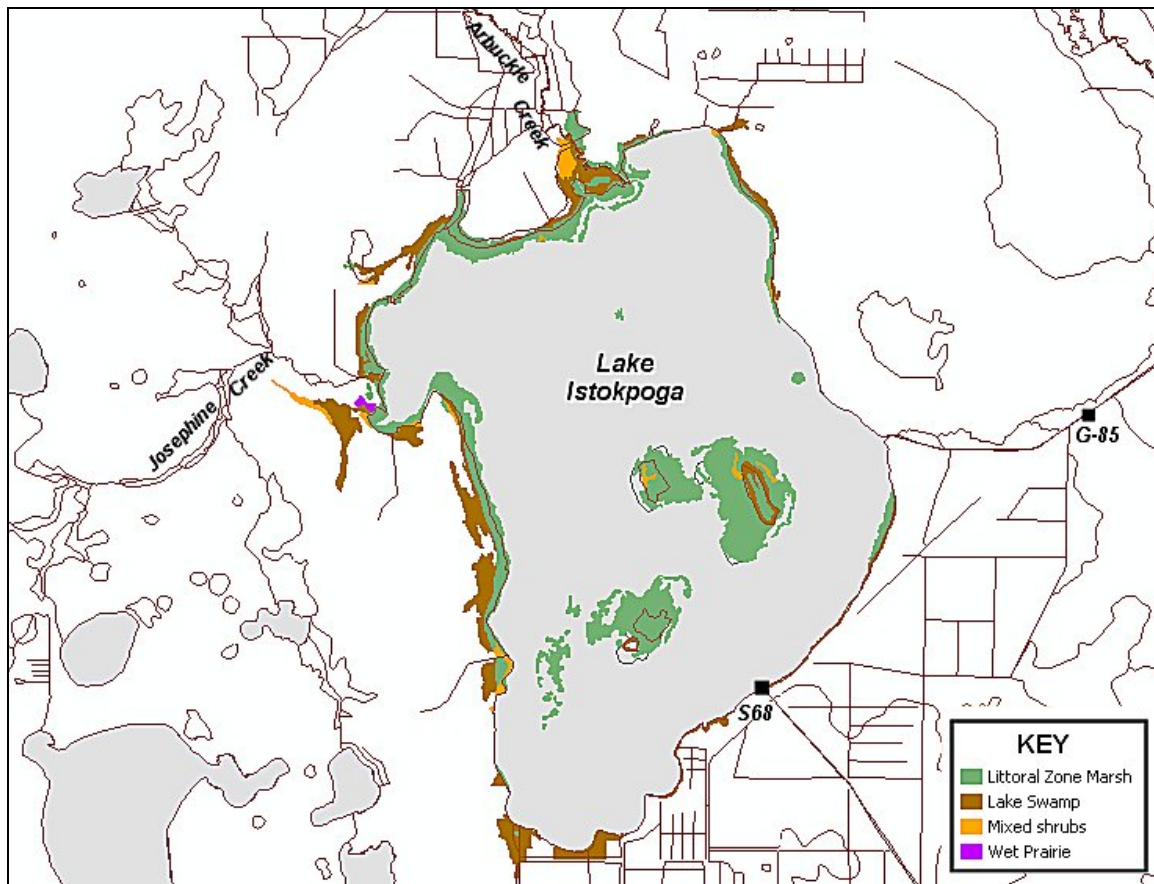
### Major Ecological Communities

The current (1995) distribution of major plant communities in Highlands County is shown in **Figure 8**. This can be compared with the historical distribution of communities (pre-development) as inferred from soil characteristics (**Figure 17**). Historically, most of the county consisted of pine flatwoods. Remnants of this community persist today in its natural state and as pastureland and rangeland. Generally, xeric communities are associated with the Lake Wales Ridge that runs from southeast to northwest in Highlands County. There are almost 99,000 acres of wetlands in Highlands County (**Table 2**), most of which are found along the Kissimmee River and Arbuckle Creek floodplains (**Figure 8**). Wetlands account for more than 15 percent of the land area. There are more acres of marshland, associated with riverine habitats, but swamp lands are also well-represented. Both wetland types are also found along the Lake Istokpoga shoreline. These diverse ecological communities represent important sources of wildlife habitat.

The general types of wetlands found along Lake Istokpoga (**Figure 18**) include marsh (typically located in the littoral zone), swamp, shrub wetlands and wet prairies. Littoral zone marsh is the most abundant wetland type (**Table 5**), encompassing more than 3,400 acres (1,400 ha). Littoral zone marsh includes emergent- and cattail-dominated wetlands. Forested wetlands (swamps) are also a dominant feature along Lake Istokpoga, although they cover about half of the area of littoral marsh. This wetland category includes swamps dominated by bald cypress, mixed hardwoods or may contain a mixture of both. Other wetland types of minor extent include shrub wetlands, usually containing wax myrtle or willow and wet prairie.



**Figure 17.** Historic Plant Communities in Highlands County Based on Soil Types (Source: Zahina *et al.* 2001a).



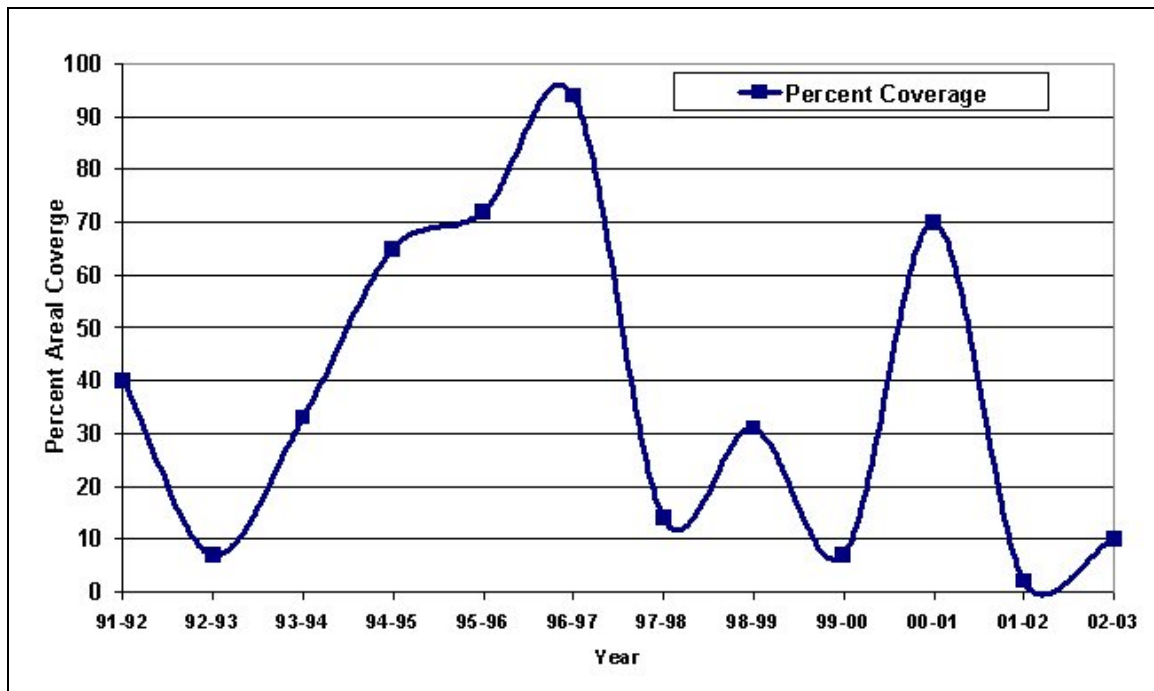
**Figure 18.** Lake Istokpoga Wetlands (Source Data: FDOT 1995).

**Table 5.** Floodplain, Littoral and Fringing Wetlands along Lake Istokpoga  
(Source Data: FDOT 1995).

Wetland Type	Area (acres)	Area (hectares)	Percent of Total Wetland Area
Littoral Zone Marsh All vegetated non-forested wetlands including emergent marsh, sloughs and cattails	3,480	1,411	64
Lake Swamp All forested wetlands including cypress, mixed and hardwood-dominated swamps	1,700	686	31
Mixed Shrubs Wetlands dominated by shrubby vegetation	260	105	5
Wet Prairie Seasonally inundated wetlands dominated by grasses	20	8	less than 1
Total	5,460	2,210	100

## Submerged Aquatic Vegetation

Common aquatic plants present in Lake Istokpoga include cattail (*Typha latifolia*), giant bulrush (*Scirpus californicus*), duck-potato (*Sagittaria lancifolia*), pickerel weed (*Pontederia cordata*), spatterdock (*Nuphar luteum*), Illinois pondweed (*Potamogeton illinoensis*), eel-grass (*Vallisneria Americana*) and bladderwort (*Utricularia sp.*) (Alam *et al.* 1996). Aquatic vegetation within Lake Istokpoga has changed significantly over the past several decades. Stabilized lake water levels have contributed to the expansion of invasive and nonnative aquatic plants. Hydrilla (*Hydrilla verticillata*) was introduced into the lake in the early 1980s; over the past decade hydrilla coverage on the lake has fluctuated, peaking in 1996–1997 where it covered approximately 94 percent (26,000 acres) of the lake’s surface (**Figure 19**). Vegetation control projects, including lake level drawdown, sediment scraping, chemical treatment, mechanical harvesting and the introduction of triploid grass carp (*Ctenopharyngodon idella*), have been somewhat successful in controlling, but not eliminating, some undesirable aquatic weeds (VanArman *et al.* 1993, FWC 2000). A large-scale vegetation management and treatment project in 2001 reduced hydrilla coverage from an estimated 19,384 acres (70% coverage) to an estimated 475 acres (2% coverage) (**Figure 19**).



**Figure 19.** Percent Hydrilla Coverage on Lake Istokpoga 1991–2003 (Source: FWC 2002).

## Littoral Zone Vegetation

A map of littoral zone vegetation communities is shown in **Figure 18**. As with the submerged aquatic vegetation, littoral zone vegetation has undergone a transformation over the past several decades. Milleson (1978) documented an increase in littoral vegetation from 2,177 ac (881 ha) in 1944 to 3,198 ac (1,294 ha) in 1975, believed to be caused by persistently lower lake levels and a reduction of the natural frequency of seasonal drying and inundation. Once dominated by duck-potato and bulrush, the shoreline now supports dense cattail or pickerel weed. During the period from 1977 to 1991, cattail coverage had increased by 87 percent (Alam *et al.* 1996).

Hydrological alterations (the lack of adequate seasonal water level fluctuations and an unnatural reversal of seasonal high and low water levels), as well as increased nutrient inputs from tributaries, also have promoted the development and expansion of floating mats of water hyacinths (*Eichhornia crassipes*) and other species common to tussock communities (O'Dell *et al.* 1995, Alam *et al.* 1996). Tussocks are generally located in shallow water (less than two feet) with expansion occurring out from the shallow fringe of the lake. In 2000, before a major tussock removal project was implemented, the rate of tussock expansion was estimated at approximately 100 acres every year (FWC 2000). Vegetation management projects have focused on reduction of tussock formation, and removal and replanting of littoral zone vegetation with desirable native species.

Development and expansion of tussocks have negative impacts on Lake Istokpoga in several ways. Due to their rapid growth characteristics, these plants deposit organic matter that forms a substrate for future tussock formation. This organic muck, which averages 1.5 feet in depth, is devoid of dissolved oxygen and is not capable of aerobic decomposition. Eventually, tussock mats form a substrate for more terrestrial plant species and the lake's shallow littoral zone becomes transformed into a marsh. Tussock expansion generally leads to loss of native littoral zone plants and a reduction of sandy benthic substrate. Loss of these native plant communities has the potential to impact fish spawning and foraging, and reduce juvenile fish habitat and waterfowl feeding areas. Dense tussocks, which can extend up to 400 yards into the lake, impact public access and navigation, degrade aesthetics and devalue lakeside property values. Although some animals exploit tussocks for nesting and protective areas, the overall ecological and economic impacts to Lake Istokpoga are strongly negative (FWC 2000).

## Fringing Swamp Vegetation

The current distribution of swamp habitat along the shoreline of Lake Istokpoga (**Figure 18**) is less than what occurred historically. Lake Istokpoga was historically surrounded by extensive bald cypress swamp (one of the largest in the interior of Florida) and swamp forest dominated by several other species, primarily located to the south and east of the lake (Brandt 1924). Those forests were almost entirely eliminated by timber operations, canal construction and agricultural development (McNair *et al.* 2001). Most forest clearing occurred from the late 1940s to the early 1960s, with smaller areas cleared



as recently as the 1970s. The extent of the fringing swamp, dominated by bald cypress (*Taxodium distichum*) and mixed swamp has remained mostly unchanged since the 1970s. However, with the stabilization of water level fluctuations over the past several decades, it has been noted that the swamp community is not reproductive (FWC 2000). Unless a suitable water regime is restored to the lake, the swamp community will eventually be replaced with other habitat types.

## Uplands

Upland communities account for approximately 12 percent (75,766 acres) of the Highlands County land area (**Table 2**). These are mostly forested lands covered with pine flatwoods, oak hammock and scrub (oak and pine). Much of the historic extent of this community type has been converted to rangeland and pasturelands. Xeric communities are associated with the well-drained dunes of the Lake Wales Ridge, which support a number of unique and federally-protected species (SCS 1980).

## Wildlife Communities

### Birds

The Lake Istokpoga area and associated wetlands support a high number of bird species. A comprehensive list of bird species documented in Highlands County was compiled from a number of sources (**Table E-1, Appendix E**). At least 75 species are believed to be breeding in Highlands County, 26 of which are associated with wetland or lake habitats (**Table E-2, Appendix E**). Many species of birds depend on a specific type of habitat for feeding and/or successful reproduction. A disturbance, whether natural or man-induced, can have a significant impact on population distribution and reproductive success. Many bird species require more than one habitat type to successfully feed, nest and rear chicks to adulthood (Ehrlich *et al.* 1988). For example, wading birds typically forage for food in marshes or in shallow open-water areas, but roost and nest in trees (Bird 1999). Some birds, such as the scrub jay (*Aphelocoma coerulescens*), are restricted to a single habitat type. Of the 26 known species of birds associated with Lake Istokpoga habitats, 21 use more than one habitat type (**Table E-2, Appendix E**).

Lake Istokpoga contains three major types of habitats that are important for a variety of bird species: 1) aquatic; 2) littoral zone; and 3) swamp. **Figure 18** shows the distribution of these habitat types around Lake Istokpoga. Aquatic habitats are open-water areas that may contain submerged vegetation. These habitats contain a wide variety of fish and numerous species of invertebrates that are important prey. The littoral zone marsh is found on the broad flats that surround the lake, and may be used for foraging, shelter and nesting sites. Fringing lake swamps are found mostly along the southern area of the lake. These areas are located behind the littoral zone and can be important roosting and nesting sites for wading birds and many raptors. A significant wading bird rookery is found on the islands in the south central area of the lake (FWC 2000). Bald eagles and very high numbers of osprey nest in the fringing swamp (Stewart 2001). Migratory birds

use the lake during the winter and waterfowl (e.g., ducks, coots) are common seasonal inhabitants.

### Fish Communities

The fish communities within Lake Istokpoga are important components of the lake's ecological community and the local economy. Small fish are important food sources for wading birds and raptors, supporting one of the largest known concentrations of osprey ever documented (Stewart 2001). Fishing and related activities support a significant recreation-based economy, ranging from sales of fishing-related equipment (from bait to boats) to fishing guide services and year-round fishing camps. The local ecological community and economy both rely on the maintenance of a healthy and productive fish community.

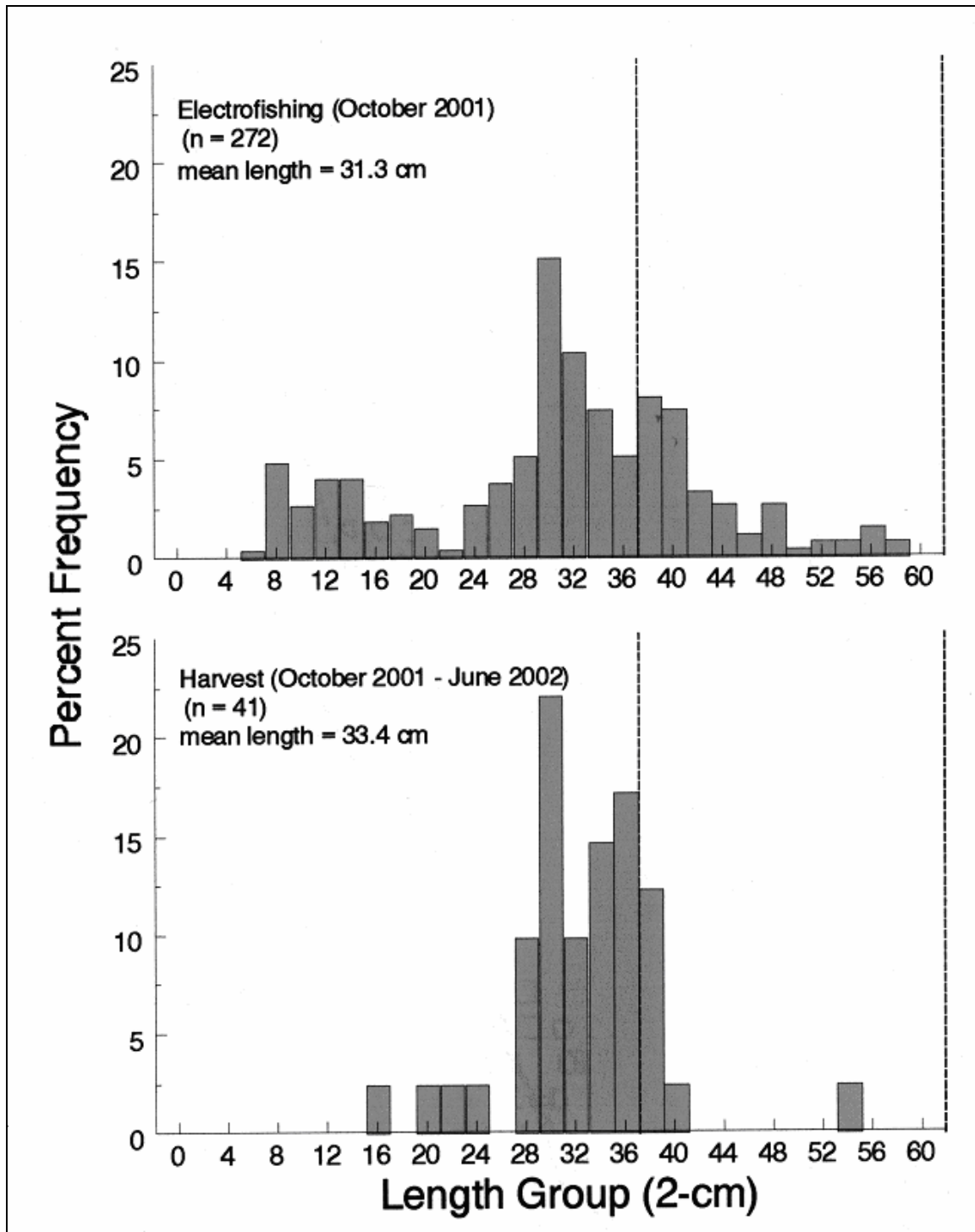
Fish surveys conducted by the Florida Fish and Wildlife Conservation Commission (FWC) during 2002 recorded 31 fish species from Lake Istokpoga (**Table 6**). Largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*) and redear sunfish (*L. microlophus*) are the four most popular species sought by recreational anglers on Lake Istokpoga and are the primary species managed by the FWC. More detailed descriptions of bass and crappie population surveys are provided below. With the exception of redear sunfish, the sportfish population of Lake Istokpoga was described as being in “good to excellent shape” (Chaupeau *et al.* 2003).

From January through April, bass spawn in bulrush and other vegetation along shallow-water areas, as well as around Big Island and Bumblebee Island. Results of electroshock and creel surveys (**Figure 20**) show that the largemouth bass population was in excellent condition with strong 1996, 1998 and 2000 year-classes. Results of fish surveys conducted during 2002 show the largemouth bass fishery on the lake to be strong two years after implementation of a slot limit and one year following a lake drawdown and habitat enhancement project. As expected the 2001 year class was weak following the spring 2001 drawdown of the lake. However, age and growth analysis conducted during 2002 indicated fast-growing, robust fish (FWC 2002).

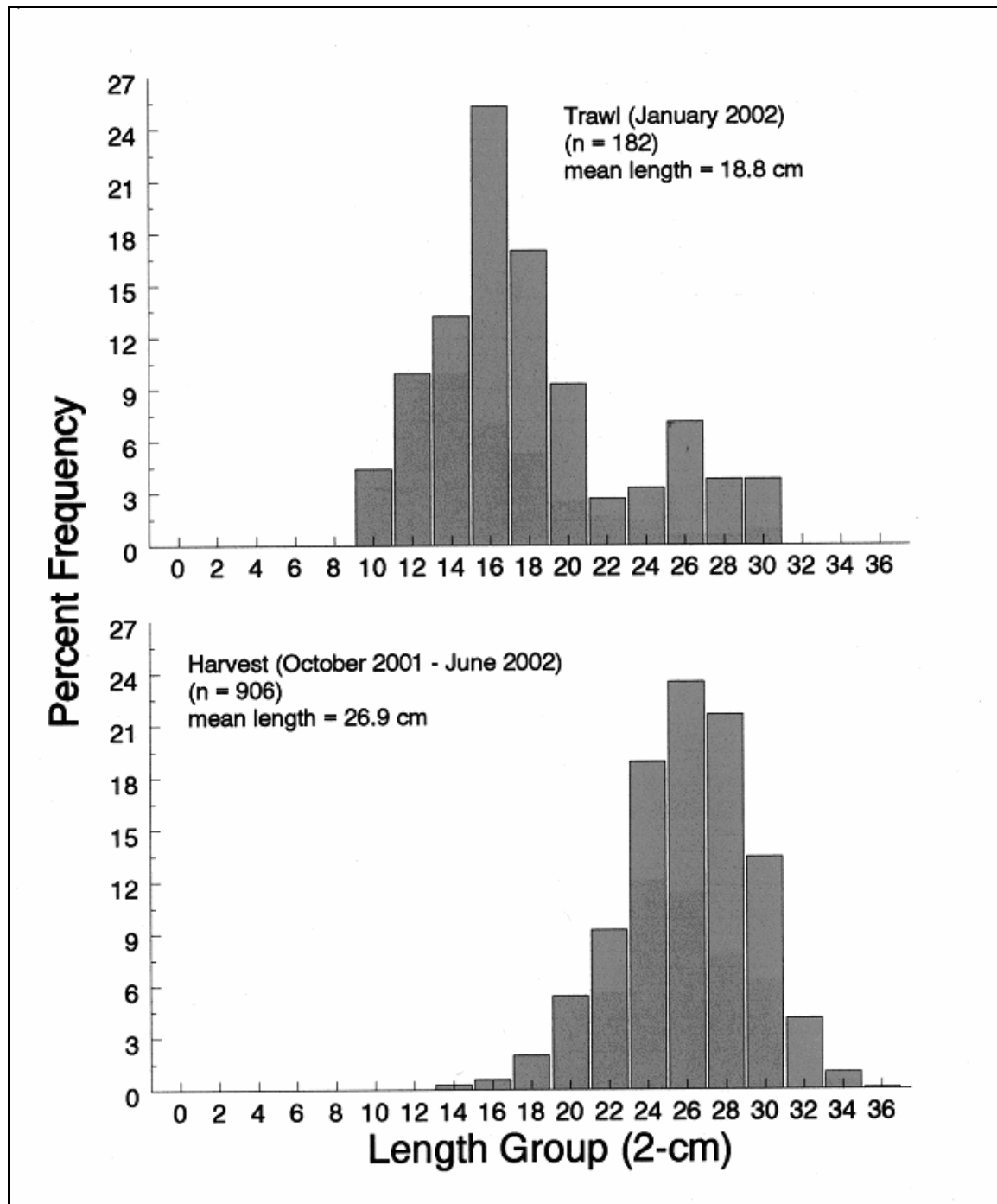
During winter as water temperatures stabilize around 65° F (18° C), crappie will move into bulrush and spatterdock areas along the shoreline to spawn. Trawl data indicate a population dominated by fish four years and younger, with relatively few over five years (FWC 2002). Trawl net and angler harvest data show strong year classes for 1999 and 2000 (**Figure 21**), while the 2001 year class was expectedly weak due to low water levels recorded during the 2001 drawdown. Crappie reach “harvestable size” (8 in or 20.3 cm) within three years and “preferred size” (10 in or 25.4 cm) within four years (FWC 2002, Gabelhouse 1984).

**Table 6.** List of Fish Species Recorded from Lake Istokpoga Using Electrofishing and Wegner Ring Catch Methods  
(Source: FWC 2002).

Atlantic needlefish ( <i>Strongylura marina</i> )	Golden topminnow ( <i>Fundulus chrysotus</i> )
Black crappie ( <i>Pomoxis nigromaculatus</i> )	Inland silverside ( <i>Menidia beryllina</i> )
Bluefin killifish ( <i>Lucania goodei</i> )	Lake chubsucker ( <i>Erimyzon sucetta</i> )
Bluegill ( <i>Lepomis macrochirus</i> )	Largemouth bass ( <i>Micropterus salmoides</i> )
Bowfin ( <i>Amia calva</i> )	Least killifish ( <i>Heterandria formosa</i> )
Brown bullhead ( <i>Ictalurus nebulosis</i> )	Pugnose minnow ( <i>Opsopoeodus emiliae</i> )
Brook silverside ( <i>Labidesthes sicculus</i> )	Redear sunfish ( <i>Lepomis microlophus</i> )
Bluespotted sunfish ( <i>Enneacanthus gloriosus</i> )	Seminole killifish ( <i>Fundulus seminolis</i> )
Chain pickerel ( <i>Esox niger</i> )	Spotted sunfish ( <i>Lepomis punctatus</i> )
Dollar sunfish ( <i>Lepomis marginatus</i> )	Swamp darter ( <i>Etheostoma fusiforme</i> )
Eastern mosquito fish ( <i>Gambusia affinis</i> )	Tailight shiner ( <i>Notropis maculatus</i> )
Everglades pygmy sunfish ( <i>Elasoma evergladei</i> )	Threadfin shad ( <i>Dorosoma petenense</i> )
Florida gar ( <i>Lepisosteus platyrhincus</i> )	Tadpole darter ( <i>Noturus gyrinus</i> )
Flagfish ( <i>Jordanella floridae</i> )	Warmouth ( <i>Lepomis gulosus</i> )
Gizzard shad ( <i>Dorosoma cepedianum</i> )	Yellow bullhead ( <i>Ictalurus natalis</i> )
Golden shiner ( <i>Notemigonus crysoleucas</i> )	



**Figure 20.** Length-Frequency Distributions (percentage, 2 cm groups) of Largemouth Bass Obtained from Electrofishing Sampling and Angler Harvest, Lake Istokpoga 2001–2002 (Source: FWC 2002); The Area within the Dotted Lines Represents Fish Prohibited from Harvest under the Protective Slot Limit on Lake Istokpoga.



**Figure 21.** Length-Frequency Distributions (percentage, 2 cm groups) of Black Crappie Obtained from Trawl Sampling and Angler Harvest, Lake Istokpoga 2001–2002 (Source: FWC 2002).



### **Plants and Animals of Special Concern**

A number of species listed by the Florida Committee on Rare and Endangered Plants and Animals (Rodgers *et al.* 1996) have significant populations within Lake Istokpoga and the surrounding uplands. The lake supports populations of aquatic species, including wading birds and limpkins, and is believed to contain one of the greatest concentration of osprey nests in the world (Stewart 2001, Pranty 2002). Other species of importance that nest along Lake Istokpoga include the least bittern, great egret, bald eagle and short-tailed hawk (McNair *et al.* 2001, Pranty 2002).

Other significant habitats for rare, threatened and endangered species are found within the Lake Istokpoga watershed. Along the western boundary of the historic Lake Istokpoga floodplain lies the Lake Wales Ridge. This unique formation was periodically isolated from the North American continent by rising sea levels during the recent ice ages. The plants and animals living in the harsh environment of those dunes were also physically and genetically isolated from the parent populations from which they descended. These isolation events allowed the development of differences that persisted when the sea levels receded and the island ridge was rejoined with North America. Many of these dune plants and animals remain restricted to the ridge habitats. The Lake Wales Ridge has one of the highest concentrations of endemic species in North America. As of 2000, there were 19 plants, three reptiles and one bird species federally-listed as threatened or endangered on the Lake Wales Ridge (SFWMD 2000a).

## **WATER QUALITY**

Water quality within the Lake Istokpoga watershed can vary considerably by site. Isolated wetlands may contain water of relatively high quality; however, water bodies that receive runoff from agricultural lands or land use types associated with high pollution loading rates may have significant water quality problems. High levels of nutrients have been implicated as the cause of the rapid growth and proliferation of aquatic weeds (e.g., cattails, water hyacinth and hydrilla) and tussocks in Lake Istokpoga. Water quality in the lake is occasionally degraded by nutrients runoff from adjacent agricultural lands (Hand *et al.* 1988).

Besides the SFWMD (e.g., Milleson 1978, Walker and Havens 2003) other groups that have conducted water quality studies in Lake Istokpoga include LAKEWATCH (Florida LAKEWATCH 2003) and the United States Environmental Protection Agency (USEPA 1977).

### **Sources of Water Quality Degradation in Lake Istokpoga**

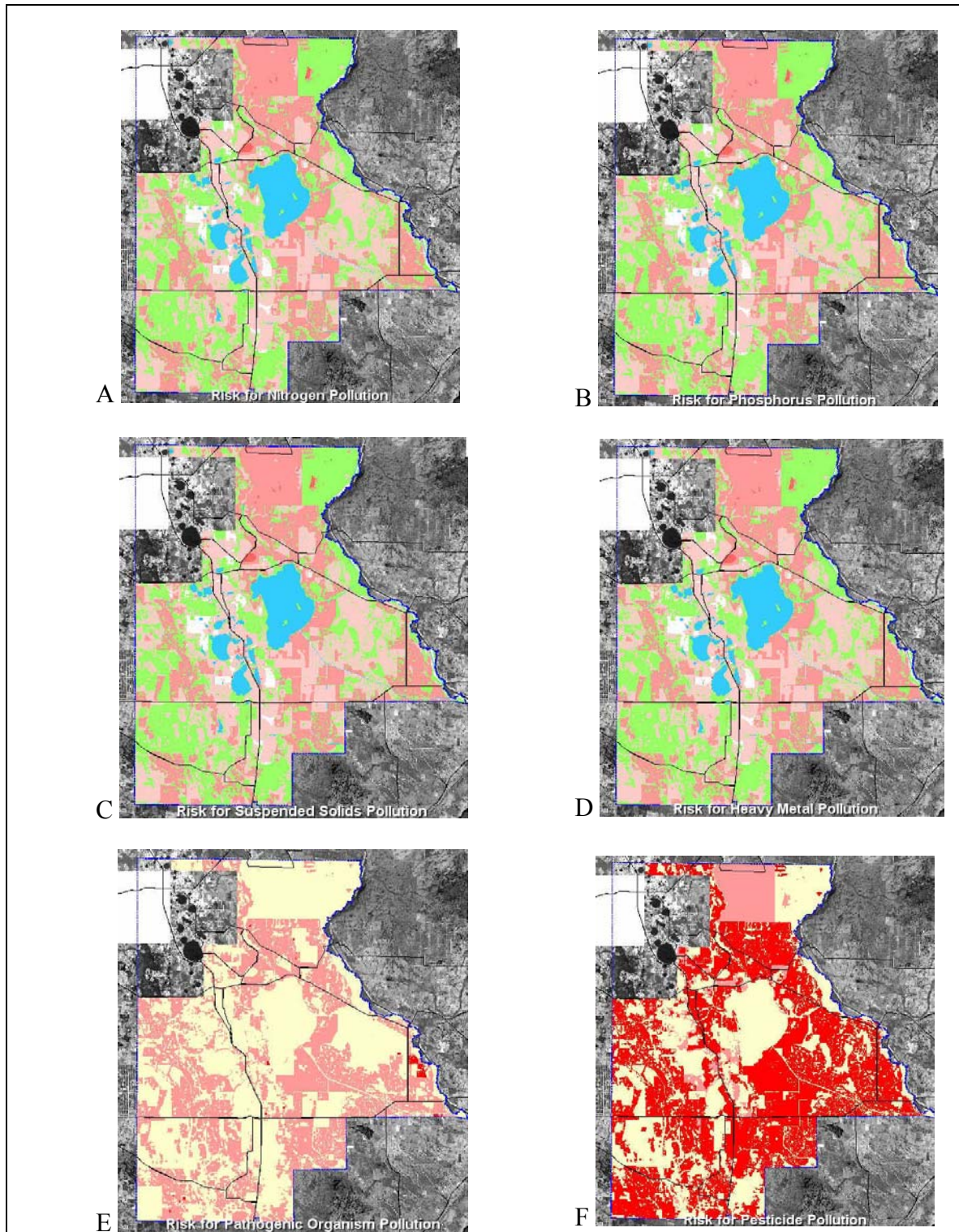
Water quality in Lake Istokpoga has been impacted by runoff from land uses surrounding the lake, as well by lake level regulation and aquatic plant management activities. Lake Istokpoga's two primary tributaries, Josephine and Arbuckle creeks at the north end of the lake, provide significant inputs of nutrients from upstream sources.

An analysis of the potential risk of pollution from land use types in Highlands County was conducted by Zahina *et al.* (2001b) and is shown in **Figure 22**. The pollution risk was calculated by the use of a pollution load screening model developed for the St. Johns River Water Management District. In this method, annual potential pollution loads were estimated using mean annual loads for land use types, average annual rainfall, soil type and the presence of on-site treatment systems. The results of the pollution risk analysis indicate that much of the area surrounding Arbuckle Creek, Lake Istokpoga and southward toward Indian Prairie has been identified as having a moderate risk for nutrient pollution (nitrogen and phosphorus) from surrounding land uses. A relatively high risk for pesticide pollution exists, based on the large extent of agricultural lands within the basin.

## Nutrients

Nutrient loading, concentrations and in-lake cycling are influenced by inputs from tributaries, stabilization of historic water level fluctuations and the extent of hydrilla. Phosphorus and nitrogen concentrations in Lake Istokpoga were studied by several authors and agencies over the past decades (**Table 7**). Although the combined volume of water inflow to the north end of Lake Istokpoga from Arbuckle and Josephine creeks is approximately equal to the outflow through the S-68 at the south end, these inflows provide 1.5 times more nitrogen and 3 times more phosphorus to the lake than is discharged out of the lake through S-68 (VanArman *et al.* 1993, O'Dell *et al.* 1995; also see Florida LAKEWATCH 2003). This is most likely the result of uptake by littoral and submerged vegetation, planktonic algae and sediments. In general, phosphorus levels at the southern end of Lake Istokpoga are reduced as compared to measurements at the north end of the lake (O'Dell *et al.* 1995). As water originating from tributaries moves south through the lake, nutrients are depleted and chlorophyll *a* concentrations increase (**Table 8**). Generally, nutrient levels in the northern portion of the lake have increased since LAKEWATCH began monitoring in 1996. This is of greater importance because water from Lake Istokpoga flows into Lake Okeechobee, which has a target total daily maximum load for phosphorus from upstream sources.

According to LAKEWATCH data, phosphorus levels at the north end of the lake range from 40 to 102 mg/m<sup>3</sup> and average 66 mg/m<sup>3</sup>, while in-lake phosphorus levels range from 16 to 85 mg/m<sup>3</sup> and average 51 mg/m<sup>3</sup> (**Table 7**). Total nitrogen in Lake Istokpoga averaged from 753 to 2,587 mg/m<sup>3</sup>. Surface water data indicates that nutrient levels increase and water clarity decreases in Lake Istokpoga following a whole-lake treatment to control hydrilla (O'Dell *et al.* 1995).



**Figure 22.** Analysis of Pollution Risk from Land Use Types in Highlands County (Source: Zahina *et al.* 2001b); Dark Red Indicates High Risk for Pollutant, Light Red Indicates Low Risk, Green Indicates No Risk and Blue Indicates Areas with No Data (A–D Only).

**Table 7.** Total Nitrogen and Phosphorus in Lake Istokpoga; Results of Present and Past Water Quality Studies.

Author and Study Period	Total N (mg/m <sup>3</sup> )	Total P (mg/m <sup>3</sup> )
US EPA, 1977 (Source: US EPA 1977)	938–1,535	37–57
Florida Dept. of Environmental Regulation, 1970–1987 (Source: Hand et al. 1988)	1,490*	60*
Florida Dept. of Environmental Regulation, 1982–1987 (Source: Hand and Paulic 1992)	975*	60–70
Milleson (SFWMD) 1973–1976 (Source: Milleson 1978)	1,028*	46*
SFWMD, 1988–1992 (Fluridone Treatment Study) (Source: VanArman 1993, O'Dell et al. 1995)		
1988 (pre-treatment)	841*	43*
1989–1992 (post-treatment)	978*	50*
SFWMD DBHYDRO Database, 1988–2003 (Data available from: <a href="http://www.sfwmd.gov/">http://www.sfwmd.gov/</a> )	500–4,230 (1,020*)	1–477 (53*)
LAKEWATCH, 1996–2002 (Source: Florida LAKEWATCH 2003)		
Lake Istokpoga	753–2,587 (1,249*)	16–85 (51*)
North Lake Istokpoga	830–1,160 (1,160*)	40–102 (66*)

\*Indicates mean for period of record.

**Table 8.** Water Clarity in Lake Istokpoga; Results of Present and Past Water Quality Studies.

Author and Study Period	Chlorophyll $\alpha$ (mg/m <sup>3</sup> )	Secchi Disc (m)
US EPA, 1977 (Source: US EPA 1997)	3.6–11.4	0.5–1.5
Canfield and Hodgson, 1983 (Source: Canfield and Hodgson 1983)	31.2*	0.50*
Florida Dept. of Environmental Regulation, 1970–1987 (Source: Hand et al. 1988)	12*	0.60*
Florida Dept. of Environmental Regulation, 1982–1987 (Source: Hand and Paulic 1992)	11–12*	0.70–0.80
Milleson (SFWMD) 1973–1976 (Source: Milleson 1978)	16.5*	0.4–0.9 (0.7*)
SFWMD, 1988–1992 (Fluridone Treatment Study) (Source: VanArman 1993, O'Dell et al. 1995)		
1988 (pre-treatment)	6.9*	1.22*
1989–1992 (post-treatment)	14.5*	0.96*
SFWMD DBHYDRO Database, 1988–2003 (Data available from: <a href="http://www.sfwmd.gov/">http://www.sfwmd.gov/</a> )	0–209 (18*)	0.1–4.3 (0.9*)
LAKEWATCH, 1996–1999 (Source: Florida LAKEWATCH 2003)		
Lake Istokpoga	Total Chlorophyll: 2.0–89.3 (34.5*)	0.4–2.0 (0.9*)
North Lake Istokpoga	5.3–74.0 (33.9*)	0.5–1.2 (0.8*)

\*Indicates mean for period of record.

## Turbidity and Color

The concentrations of planktonic algae (i.e., living as free-floating within the water column) are often used as indicators of nutrient enrichment of surface waters. Excessive algae concentrations reduce water clarity and, in extreme cases, can lead to depletion of oxygen levels and fish kills. Algae levels, which are usually estimated from chlorophyll  $\alpha$  concentrations in water samples, typically fluctuate with nutrient levels (**Table 8**). Chlorophyll  $\alpha$  levels in Lake Istokpoga, as reported by LAKEWATCH, were slightly higher in northern Lake Istokpoga than for the rest of the lake, indicating an effect from tributary inputs. Chlorophyll  $\alpha$  levels increased following Fluridone treatment of the lake to control hydrilla, most likely due to degradation of plant materials and release of nutrients.

Water clarity is often measured by the “Secchi Disk” method, where a standardized disk is lowered into the water to the greatest depth at which markings on the disk can no longer be distinguished. Water clarity, as measured by LAKEWATCH and determined by Secchi depths, is lower in the northern area of the lake as compared to other lake sites (**Table 8**). A decrease in water clarity was also observed following treatment of the lake with Fluridone. These observations can be attributed to the effects of lowered water quality from tributary inputs, proliferation of planktonic algae and the decay of aquatic vegetation following treatment.

## Oxygen, pH and Temperature

**Table 9** shows the measured values for oxygen, pH and temperature for Lake Istokpoga and its main tributaries. These data are available from the SFWMD’s corporate environmental database called DBHYDRO, but data were acquired by a monitoring program for the lake. Generally, dissolved oxygen levels were higher in the lake than in the tributaries. These differences may be due to the high amount of phytoplankton, submerged vegetation and algal epiphytes found within the shallow Lake Istokpoga. Arbuckle and Josephine creeks have relatively little submerged aquatic vegetation, may be sites for groundwater inflows and tend to have poorer water quality, conditions that would support lower oxygen concentrations. Measured pH values were circum-neutral for both the lake and tributary waters, probably due to the fact that most Florida surface waters tend to be well buffered. Temperature varied little between water bodies.

**Table 9.** Oxygen and pH in Lake Istokpoga and its Tributaries; Values are Mean for the Period of Record (1989–2003) with Standard Deviation  
(Source: SFWMD’s DBHYDRO Database).

	Oxygen (mg/L)	pH	Temperature (Celsius)
Lake Istokpoga	8.2 $\pm$ 1.4	7.6 $\pm$ 0.8	24.9 $\pm$ 4.9
S-68	7.8 $\pm$ 1.5	7.6 $\pm$ 0.7	25.1 $\pm$ 5.1
Arbuckle Creek	4.9 $\pm$ 2.0	6.5 $\pm$ 0.6	24.9 $\pm$ 4.5
Josephine Creek	5.2 $\pm$ 1.6	6.1 $\pm$ 0.6	24.5 $\pm$ 4.1



## WATER RESOURCE ISSUES

### Overview of Consumptive Uses within the Watershed

The driving force behind urban water demand is population. Population in the Kissimmee Basin Planning Area is projected to increase by almost 90 percent by 2020 (SFWMD 2000a). Although most of this population increase is projected to occur within the northern urban areas of this planning area (Orange and Osceola counties), the southern portion (including Lake Istokpoga) is projected to have only a modest increase in residents. The *Kissimmee Basin Water Supply Plan* (SFWMD 2000a) projects an increase in Highlands County residents from 7,700 (1995) to approximately 11,600 (2020). There are no municipalities in the Highlands County area (i.e., the area of Highlands County within the SFWMD jurisdiction).

Agricultural activity represents the single largest water use type in the Lake Istokpoga area. The primary land use in the Lake Istokpoga basin is agricultural, dominated by citrus groves, improved pasture and truck farming (McDiffett 1981). Citrus and ornamental plant farms are typically found on the Lake Wales Ridge to the west and drained lands to the south of Lake Istokpoga, respectively. The number of acres of irrigated citrus in the Highlands area is expected to increase from 39,324 acres (1995) to more than 61,000 acres (2020) (SFWMD 2000a).

The Brighton Indian Reservation is located south of Lake Istokpoga within the Lake Istokpoga-Indian Prairie Basin and is supplied with water mostly from Lake Istokpoga through the C-41/C-40 Canals. The reservation was established in 1938 and currently has a population of about 500. The reservation covers almost 36,000 acres, primarily agricultural, including improved pasture, citrus, sugarcane and aquaculture. The Lake Istokpoga-Indian Prairie Basin has historically experienced water shortages. The Seminole Tribe of Florida, the State of Florida and the SFWMD executed a Water Rights Compact in 1987. This Compact establishes, among other things, the Tribe's water entitlement for the Brighton Reservation. A subsequent agreement (Number C-4121) was executed in the early 1990s and further defined the Tribe's water rights (see **Appendix A** for details on this agreement).

### Lake Istokpoga-Indian Prairie Basin Surface Water Analysis

For the past decade, the use of additional surface water from the Lake Istokpoga-Indian Prairie Basin has been restricted as a result of several water shortages that occurred in the area during the 1980s. As part of the Kissimmee Basin Water Supply Plan planning effort, an evaluation of the water use problems of the Lake Istokpoga-Indian Prairie Basin and recommendations regarding alternate water supply sources were completed (SFWMD 2000a). Under that analysis the Lake Istokpoga-Indian Prairie Basin was defined as the area having access to the C-40, C-41 and C-41A canals or Lake Istokpoga, either directly or via other canals. The analysis included both statistical and empirical methods to estimate discharges from the control structures. The statistical

approach attempted to develop a mathematical correlation between rainfall patterns and releases from the control structures. The empirical approach reviewed 20 years of records to find years that matched the seasonal rainfall conditions of a 1-in-10 year drought. The statistical approach was found to track the trends in discharge relatively well, but had less success in matching month-to-month values and extreme discharge events.

The analysis evaluated water availability in the basin during a 1-in-10 year drought condition. The analysis assumption was that the drought was preceded by an average rainfall year and the water level of Lake Istokpoga was at or near its average level at the end of the wet season in October. A presumption in the analysis was that water currently released from the basin to either Lake Okeechobee or the Kissimmee River south of S-65D could be used as the first source in meeting the projected demands. In the first part of this analysis, the amount of discharge leaving the basin through water control structures S-68, S-71, S-72 and S-84 was quantified for the 1-in-10 year drought condition. The second effort of the analysis determined if additional supplies could be released from Lake Istokpoga, while maintaining the required minimum operational schedule and minimum canal levels set forth in the Water Shortage Rule 40E-22, F.A.C

The analysis contained three major components: estimation of the 1-in-10 year water demands, determination of 1-in-10 year drought discharges from the basin under the existing operation/management and analysis of alternative sources. Water use estimates were made for two major categories of water use: urban and agriculture. Urban use was divided into five categories, with all except public water supply considered self-supplied. Agricultural water use is water used for crop irrigation and cattle watering, and water used in facilities supporting these activities. All water use demands were calculated on a monthly basis using a statistically derived 1-in-10 year drought condition.

The results of the analysis showed the need for the release of an additional 17,069 acre/ft of water from Lake Istokpoga in 2020, above the historic 1-in-10 year releases, to meet additional needs for the Indian Prairie Basin during a 1-in-10 year drought. This release, in combination with back pumping from Lake Okeechobee, was determined to meet the 2020 demands for this planning area. During average rainfall conditions, no additional releases from Lake Istokpoga beyond those currently delivered are anticipated. Anticipated water supply needs are addressed in the *Kissimmee Basin Water Supply Plan* (SFWMD 2000a).

## Input of Nutrients and Pollutants

Water quality in Lake Istokpoga has been impacted directly by runoff from land uses surrounding the lake and less directly by lake level regulation and aquatic plant management activities. Water quality monitoring programs are ongoing and efforts to deal with point-source pollution have been initiated. Water quality in Lake Istokpoga has implications for controlling nutrient levels in the Kissimmee River and Lake Okeechobee, the latter having a total daily maximum load established for phosphorus. A summary of Lake Istokpoga area projects that examine water quality issues can be found in the “Lake Istokpoga Resource Protection Projects” section at the end of this chapter.

## Navigation and Recreation

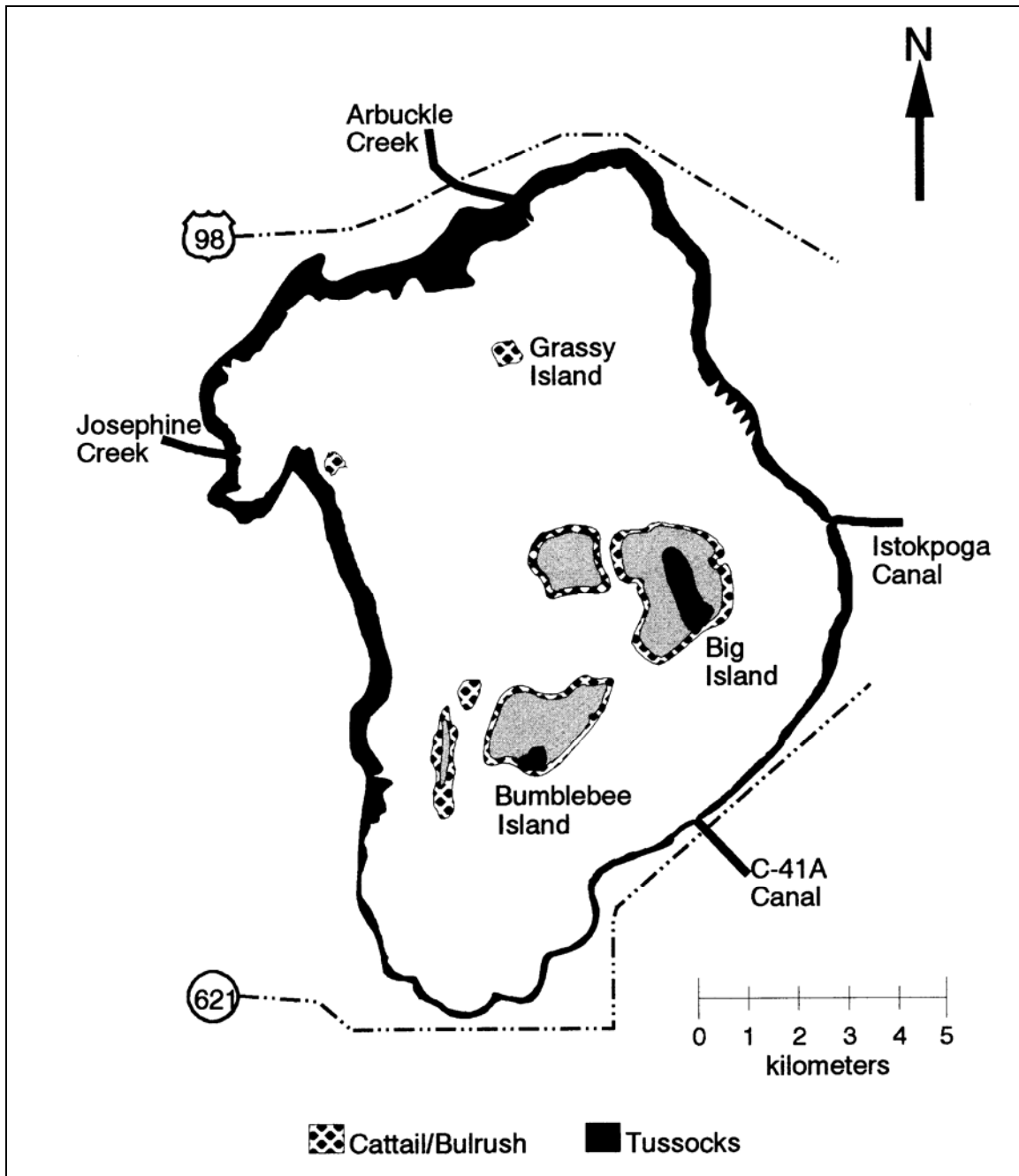
Navigation and recreation in Lake Istokpoga can be impacted both by stabilized water levels and low water levels. Stabilized water levels promote the proliferation of cattail, tussocks and hydrilla, which can create serious physical barriers to navigation by motor powered crafts. Navigation access to the lake from spur canals can be restricted by low water levels.

Recreation on Lake Istokpoga is indirectly impacted by stabilized water levels. The formation of tussocks and proliferation of hydrilla can have negative impacts on the quality of fish habitats. Periodic drawdowns and control of nuisance vegetation, such as have been done on other Florida lakes, have been shown to improve the quality of aquatic habitats and can benefit the long-term viability of fish communities (see Florida Game and Freshwater Fish Commission 1994).

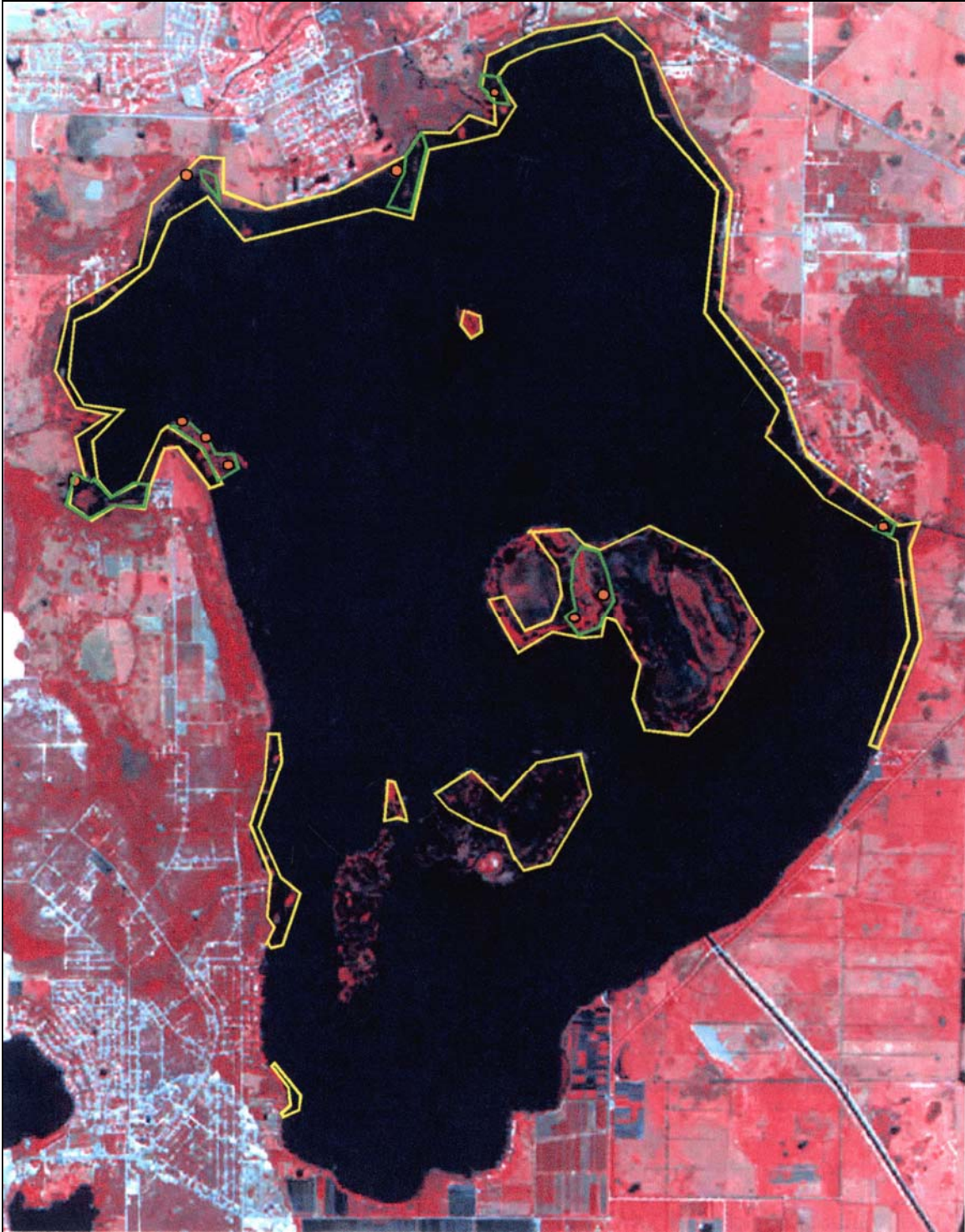
## Aquatic Habitat Management Program

An aquatic habitat enhancement program was conducted on Lake Istokpoga by the FWC during the winter and spring of 2001. Objectives of the project were to restore fish and wildlife habitat, improve water quality and enhance flood protection and navigation within the lake. **Figure 23** provides a fish management area map showing the location of cattail and bulrush tussocks that were targeted for enhancement prior to the lake's drawdown (FWC 2002).

A window of opportunity for enhancing lake vegetation presented itself during the drought of 2000–2001. Low lake stages favored implementation of an aquatic habitat management drawdown project two years earlier than originally planned. The SFWMD provided \$3 million to fund this project. Aggressive collaboration by the FWC, SFWMD, USACE, FDEP, Highlands County Board of County Commissioners and other cooperating agencies allowed the FWC to put this plan into operation in less than two months after the opportunity arose. Using earth-moving equipment, an estimated 1,309 acres (530 ha) of fish and wildlife habitat was restored through scraping and removal of 2,463,797 yards<sup>2</sup> (1,883,708 m<sup>2</sup>) of tussock and organic sediments from the dry lake bottom. The project resulted in restoration of about two-thirds of the lake's shoreline littoral zone (**Figure 24**). One third of the harvested material was removed from the lake and placed at 16 upland storage sites. Thirty-six "wildlife islands" (in-lake disposal sites) were constructed during the project. The project focused on removal of 100 acres (40.5 ha) of cattail tussocks and associated organic sediments around Big Island marsh and the northwest shoreline using mechanical weed harvesters. This material was consolidated on the in-lake wildlife islands.



**Figure 23.** Lake Istokpoga Fish Management Area (Source: FWC 2002).



**Figure 24.** Satellite Image of Lake Istokpoga; Areas Outlined in Green Represent Sites with Tussock Harvesting by Aquatic Weed Harvesters, Areas Outlined in Yellow Represent Sites with Herbicide Treatment of Invasive Aquatic Plants, Orange Circles Represent In-Lake Consolidation Islands (Source: FWC 2002).



In addition to mechanical harvesting, chemical treatment was used to reduce the extent of undesirable plants. Whole-lake treatment with Fluridone was used to control hydrilla. Dense stands of cattail, pickerel weed and burhead sedge (*Oxycaryum cubense*) were treated with herbicides. This included an area of 2,450 acres (991.5 ha) located around Big Island and Bumblebee Island marshes. Dense cattail stands were sprayed by helicopter with some sparse cattail bands left intact for use by fish, wading birds and waterfowl. **Figure 24** shows those areas of the lake enhanced by herbicide treatment.

Follow-up studies conducted by the FWC during 2002 showed that the enhanced areas of the lake were colonized by pickerel weed, duck-potato, torpedo grass (*Panicum repens*), eel-grass, coontail (*Ceratophyllum demersum*) and hydrilla. The chemical treatment reduced hydrilla coverage from an estimated 19,384 acres (70% coverage) recorded in 2000–2001 to an estimated 475 acres (2% coverage) recorded during the post drawdown/post treatment period of 2001–2002 (**Figure 19**). Fish surveys conducted within the enhanced areas showed increased fish species diversity, species richness and abundance in response to the colonization by emergent and submersed aquatic macrophytes (FWC 2002).

Overall, the aquatic habitat enhancement program has been recognized as an excellent example of interagency teamwork. Many local, state and federal agencies worked together, along with citizen groups, to help ensure the health of Lake Istokpoga's \$6 million annual sport fishery (Champeau *et al.* 2004) and associated wildlife habitat. The total cost of the project was \$2,740,320 (FWC 2002).

## Fisheries Management

The Division of Fisheries Management of the FWC lists Lake Istokpoga as one of Florida's top ten lakes for catching largemouth bass, black crappie and bluegill (see <http://www.floridafisheries.com/>). The black crappie fishery has peak catch rates during the winter months. Bluegill fishing is also popular with late spring and summer producing best results. A Florida Game and Freshwater Fish Commission (now the Florida Fish and Wildlife Conservation Commission or FWC) creel survey conducted during 1991–1992 documented an hourly catch rate of 0.41 bass per hour, which was nearly double the statewide average (FWC 2002).

On July 1, 2000 the FWC implemented a protective slot limit on the size and number of largemouth bass harvested from the lake. In order to maintain the lake's high-quality largemouth bass fishery, the FWC instituted a 15 to 24 inch (38 to 61 cm) protective slot limit with a three fish bag limit, of which only one bass may exceed 24 inches (61 cm). The objective of this regulation was to manage for a high-quality largemouth bass fishery, while allowing the harvest of more abundant, smaller-sized bass and still allow for "catch of a lifetime" trophy-sized fish to be harvested (FWC 2000).

The FWC has issued a mercury warning for Lake Istokpoga. Consumption of largemouth bass should be limited by women of childbearing age and children under age ten should not eat more than 8 ounces of bass over a four-week period. All others should

limit consumption of bass from these areas to no more than 8 ounces a week (<http://www.floridafisheries.com/>). Analysis of the mercury content of Lake Istokpoga bass revealed an overall reduction in mercury content since 1989. The lake however, will remain on the “Limited Consumption” list due to the 0.51 ppm mercury levels detected in bass exceeding 35.6 cm in length (FWC 2002).

In 2002–2003, the recreational fishery was strong with high angler effort and success observed for both the largemouth bass and black crappie. Angler catches and success for largemouth bass remained good with angler success rates of 0.45 fish/hour recorded (**Table 10**). Catches of high quality and trophy bass were also very good. “High-quality” bass continue to make up a large proportion of tournament caught fish since implementation of the protective slot limit (FWC 2000). In comparison to pre-drawdown and pre-slot limit values, angler effort and catches for largemouth bass were down slightly; however, the crappie fishery had returned to pre-drawdown levels. The bluegill fishery experienced a dramatic increase after the drawdown providing excellent angler success (**Table 10**). In contrast, angler effort and harvest for redear sunfish were nominal. Fish sampling in areas enhanced by the drawdown were indicative of quality fish habitat and a diverse fish community. These areas exhibited oxygen levels and hard sand substrate necessary for good spawning habitat. The economic value of the fishery in those areas of the lake enhanced by the drawdown was estimated to average \$25,961.42 per hectare during the fall and \$39,269.70 per hectare during the spring of 2002 (FWC 2002).

## LAKE ISTOKPOGA RESOURCE PROTECTION PROJECTS

### Kissimmee Basin Water Supply Plan Update (2005)

Water supply plans are water resource planning efforts designed to identify water needs over a 20-year time frame and projects that are proposed to meet those needs. The SFWMD completed the first Kissimmee Basin Water Supply Plan (KB Plan) in 2000 and a 2005 update is currently being compiled.

The Kissimmee Basin is one of four regional planning areas in the SFWMD. The Kissimmee Basin Planning Area covers approximately 3,500 square miles and includes parts of Orange, Osceola, Polk, Highlands, Okeechobee and Glades counties. This planning area also shares common boundaries with adjacent water management districts, the St. Johns River Water Management District along the east and north, and the SFWMD along the west.

**Table 10.** Lake Istokpoga Hydrilla Coverage (acres) and Angler Success for Sportfish Species (Source: FWC 2003).

Year (Nov–March)	Hydrilla Coverage		Angler Success (fish/hour)		
	# Acres	Percent (coverage)	Largemouth Bass	Black Crappie	Bluegill and Red Eared Sunfish
1991–1992	11,000	40%	0.37	1.60	1.76
1992–1993 (Post-treatment)	2,000	7%	0.30	1.85	0.67
1993–1994	9,000	33%	0.30	1.44	1.43
1994–1995	18,000	65%	0.22	1.90	1.62
1995–1996	20,000	72%	*ND	ND	ND
1996–1997	26,000	94%	ND	ND	ND
1997–1998	3,823	14%	0.50	2.71	5.05 B 2.18 R
1998–1999	8,538	31%	0.51	2.12	3.03 B 1.25 R
1999–2000 (Post treatment)	1,896	7%	0.46	2.72	5.63 B 1.29 R
2000–2001 Drawdown and slot limit implemented	19,384	70%	0.74	2.53	2.67 B 0 R
2001–2002 Post-drawdown Post-treatment	475	2%	0.45	2.07	3.11 B 0.37 R
2002–2003 Hydrilla treatment	2,873	10%	0.45	1.75	4.91 B 1.71 R

\*ND = No data collected

Each of the three water management districts has identified areas that may experience harm to natural resources due to future water withdrawals. In the northern counties of the planning area, groundwater withdrawals by municipalities are the largest risk. In portions of Highlands and Glades counties, surface water supplies from Lake Istokpoga are limited (see **Appendix D** for dry season water availability and consumptive use permit allowances). The SWFWMD has identified several stressed lakes along the Lake Wales Ridge, which have been linked to declines in Floridian Aquifer levels.

The purpose of the KB Plan is to provide a framework for future water use decisions and to provide adequate water supply for urban areas, agriculture and the environment over the next 20-year planning horizon. The plan estimates the future water supply needs of urban areas and agriculture, weighs those demands against historically used water sources and identifies areas where these demands cannot be met without possible harm to the resource and environment, including wetlands. The plan evaluates the potential of several alternative water source options to meet any unmet demand and makes recommendations for their development.

The plan's objectives include the following:

- Optimize use of all water sources.
- Protect natural systems from harm due to water uses.
- Identify options that will provide a 1-in-10 year level of certainty for all existing and projected reasonable-beneficial uses.
- Promote compatibility of the KB Plan with tribal and local government land use decisions and policies.
- Promote compatibility and integration with other related regional water resource efforts.
- Promote water conservation and efficient use of water sources.
- Refine water supply demand projections for all reasonable-beneficial uses for average year and the 1-in-10 year level of certainty.
- Identify adequate sources of funding to support water resource development and water supply development options identified in the plan.
- Protect water resources from harm due to water uses.

The SFWMD's water supply planning functions are guided by the directives and policies of the SFWMD's Water Supply Policy Document (SFWMD 1991), State Water Policy (Chapter 62-40, F.A.C.), Chapter 373, F.S., the State Comprehensive Plan (Chapter 187, F.S.) and delegation of authority from the Florida Department of Environmental Protection (FDEP). In addition, the plan meets the legislative requirements of the 1996 Governor's Executive Order 96-297 and the 1997 water supply planning provisions of Section 373.0361, F.S.

## **Southern Indian Prairie Canal Basin Operation Plan**

The purpose of this plan is to implement some of the recommendations in the *Kissimmee Basin Water Supply Plan*. The project will evaluate the installation of additional pumps to move water from Lake Okeechobee to provide water supply upstream of S-82 and S-83 in the southern Indian Prairie canal basin. The operation of existing pumps will be evaluated to determine the need for new pumps in light of Seminole water rights/needs, operational levels, potential land acquisition requirements, monitoring requirements, first cost and operating costs and related issues, such as water quality, flood control and environmental concerns. This project will not modify the SFWMD-Seminole agreement, address Total Maximum Daily Load (TMDL) requirements, recompute irrigation demands, investigate water availability from Kissimmee or evaluate other water supply sources.

## **Lake Istokpoga Aquifer Storage and Recovery**

This project will investigate the feasibility of aquifer storage and recovery (ASR) for Lake Istokpoga. The project is a response to Recommendation 5.2 of the Kissimmee Basin Water Supply Plan and is expected to be completed in cooperation with the SWFWMD. Initial stages of the feasibility study are looking towards the water quality and hydrological studies being completed for Lake Okeechobee.

## **Lake Okeechobee Watershed CERP Project**

The Lake Okeechobee Watershed (LOW) Project is part of the greater Comprehensive Everglades Restoration Plan (CERP), which is a group of projects designed to be a framework and guide to restore, protect and preserve the water resources of central and southern Florida. The CERP has been described as the world's largest ecosystem restoration effort and includes more than 60 major components.

The purpose of the LOW Project is to improve the water quality of Lake Okeechobee, provide for better management of lake water levels and reduce damaging releases to the estuaries. Water from the watershed and the lake will be detained in large storage areas during wet periods for later use during dry periods. The LOW Project study area was initially divided into four interconnected planning areas. The evaluation criteria previously developed were focused on issues associated with these four hydrologically distinct regions. A fifth planning area, the Lake Istokpoga Watershed, was subsequently added to the project study area. As part of the LOW project, the Lake Istokpoga Regulation Schedule will reexamine the Lake Istokpoga Basin focused on creating a balance among the environmental, water supply and flood control needs in the drainage basin. The plan will address the need for flood protection for the perimeter and upstream tributaries, and for downstream areas west and east of the C-41A Canal. The plan will also address water supply needs of both agricultural users and the Seminole Tribe of Florida.

## **Kissimmee River Restoration Project**

This is a joint U.S. Army Corps of Engineers–SWFWMD project to restore large areas of the historic Kissimmee Lakes and River wetland system. The upper basin portion of the project consists of water regulation schedule modifications, canal and structure improvements and land acquisition. This will reestablish natural timing and volumes of flows into the Kissimmee River and will provide more natural fluctuations of water levels to enhance the peripheral marshes of the lakes. Backfilling C-38 in Pools B, C and D and the restoration of flows through the meandering river channel will create historic hydrological conditions in the floodplain to enhance fish and wildlife habitat.

The Kissimmee River Restoration will result in higher water levels in Pool C, downstream of G-85. As a result, flood discharge capacity from Lake Istokpoga to the Kissimmee River could be reduced. In order to maintain the existing Lake Istokpoga

flood discharge capacity, G-85 will be replaced with S-66 and a portion of the Istokpoga Canal will be improved. Additionally, S-68, S-83 and S-84 will be modified to provide additional discharge capacity.

## **Phosphorus Budget and Loading Analysis for Lake Istokpoga and the Upper Kissimmee Watersheds**

This project will assess the sources of phosphorus from Lake Istokpoga (and Upper Kissimmee Lakes) and the relative contribution to the water quality of Lake Okeechobee as required by the Lake Okeechobee Protection Act. The project will: identify contributing basins (including Lake Istokpoga) and define the drainage boundaries; conduct a mass balance analysis of phosphorus for each land use at the basin and watershed scale; analyze possible relationships between net phosphorus imports and basin characteristics (land use, soil type, etc.); and prepare documentation.

## **Lake Istokpoga Phosphorus Study**

This project will determine whether reductions in external phosphorus loading to Lake Istokpoga will result in corresponding reductions to phosphorus loads to Lake Okeechobee. It will determine: physical and chemical characteristics of in-lake sediment; assimilative capacity of the sediment; how long the assimilative capacity will last; the current contribution of phosphorus from sediments to the water column; and the effect a reduction in external loading may have on phosphorus discharges.



